

FLORIDA HOUSE OF REPRESENTATIVES

COMMITTEE ON WATER & NATURAL RESOURCES INTERIM PROJECT 2004-2005



IMPACTS OF THE NET BAN CONSTITUTIONAL AMENDMENT

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1101 The Capitol**

February 2005

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INTERIM PROJECT REPORT

February 2005

Prepared by
The Staff of the House Committee on Water & Natural Resources

EXECUTIVE SUMMARY

In 1994, an amendment was adopted to the Florida Constitution to limit the use of nets by commercial fishermen in marine waters. This was the so-called "net ban" amendment. The purpose of the amendment was primarily to protect saltwater finfish from overfishing.

Based on the available data, it now appears that for certain selected species of fish that purpose has been accomplished. There is as yet insufficient data to determine whether any other species are still overfished.

There is a growing body of evidence that recreational fishing is having an increasing impact on fish stocks relative to the impacts from commercial fishing. Therefore, any future efforts to assess the impacts of fishing on fish stocks should include the impacts from recreational fishing.

It must be recognized that the success of the net ban amendment in reducing overfishing has come with a significant negative impact on the commercial fishing interests in Florida. These have been the economic and social impacts experienced by commercial fishing families and local coastal fishing communities.

INTRODUCTION

The Constitutional Amendment

In 1994, an overwhelming majority of Florida voters voted to amend the Florida Constitution by adopting the “Limiting Marine Net Fishing Initiative,” which provides, in part, that

The marine resources of the State of Florida belong to all of the people of the state and should be conserved and managed for the benefit of the state, its people, and future generations. To this end the people hereby enact limitations on marine net fishing in Florida waters to protect saltwater finfish, shellfish, and other marine animals from unnecessary killing, overfishing and waste.

This Initiative is now found in Section 16, Article X of the Florida Constitution (hereinafter referred to as the “Net Ban Amendment”). The Net Ban Amendment can be summarized as follows:

- It prohibits the use of gill and other entangling nets in Florida waters;
- It prohibits the use of other nets larger than 500 square feet in mesh area within three miles seaward of the Gulf of Mexico coastline and within one mile seaward of the Atlantic coastline;
- It prohibits the use of more than two unconnected nets from a vessel;
- It allows a person who is not on a vessel to use only one net in nearshore and inshore waters;
- It defines “gill net” as one or more walls of netting which captures saltwater finfish by ensnaring or entangling them in the meshes of the net by the gills;
- It defines “entangling net” as a drift net, trammel net, stab net, or any other net which captures marine animals by causing all or part of the body to become entangled or ensnared in the meshes of the net;
- It excludes hand-thrown cast nets from the definitions of gill and entangling net;
- It provides specific criteria for measuring mesh area and defines “mesh area” as the total area of netting with the meshes open to comprise the maximum square footage; and
- It does not prohibit the establishment by law, or pursuant to law, of more restrictions on the use of nets.
- It became effective July, 1, 1995.

Statutes and Rules Implementing the Constitutional Amendment

The Net Ban Amendment was implemented through Sections 370.092 and 370.093, F.S. Section 370.093, F.S., prohibits attempts to take, and the taking of, marine life using any net and attachments not approved by the Florida Fish and Wildlife Conservation Commission (“FWCC”) that, when combined, are larger than 500 square feet. This section also prohibits the use of certain nets constructed wholly or partially of monofilament or multistrand monofilament material. Upon the arrest of any person for

violations of this section, the arresting officer must seize the illegally used nets and destroy the nets upon conviction of the offender. The FWCC is specifically authorized to adopt rules implementing the provisions of this section and the prohibitions and restrictions of the Net Ban Amendment. Violations of this provision are punishable as provided in s. 370.021(3), F.S.

Section 370.092, F.S. regulates the carriage of proscribed nets across Florida waters. Except under specified circumstances, vessels are prohibited from transporting across Florida waters gill and entangling nets prohibited by the Net Ban Amendment. In addition, this provision prohibits possession of a gill or entangling net, or any seine net larger than 500 square feet in mesh area, on certain vessels. The FWCC is specifically authorized to adopt rules prohibiting possession and sale of mullet taken in illegal nets, and to adopt rules implementing the provisions of this section. Violations of this provision are punishable as provided in s. 370.021(3), F.S.

The FWCC has adopted several rules implementing the Net Ban Amendment and related statutory provisions, including the following:

- Chapter 68B-4.0081, F.A.C.- Gear Specifications and Prohibited Gear (Provides general definitions related to nets, regulates carriage of nets across Florida waters, and prohibits the use of certain nets.)
- Chapter 68B-35, F.A.C. - Pompano, African Pompano, and Permit (Establishes specifications for gear, including nets.)
- Chapter 68B-39.0647 - Mullet (Establishes specifications for gear, including nets.)

As noted above, the stated purpose of the Net Ban Amendment was “to protect saltwater finfish, shellfish, and other marine animals from unnecessary killing, overfishing and waste.” This report looks at the impact that the net ban has had on the recovery of the saltwater finfish stocks since its implementation in 1995 and gives a brief overview of the economic and social impacts of the net ban on the commercial fishing industry.

I. IMPACTS ON THE RECOVERY OF FISHERIES

Commercial Trips and Landings

In 2000 the Florida Marine Research Institute (FMRI) attempted to measure the impact that the implementation of the Net Ban Amendment had on the recovery of fish populations that ostensibly had been adversely impacted by commercial net fishing. They did this by reviewing the available data from the three years immediately preceding the “net ban” (1992 – 1994) and comparing that data to three years after the “net ban” (1997 – 1999). The years 1995 and 1996 were not included since those were transition years.¹ The FMRI looked at the commercial landings and trips for 18 species of fish that were caught primarily by nets prior to the implementation of the “net ban.” This exercise was repeated in 2004 looking at the same data for the three years 2001 - 2003.² The theory behind the research is that in order to have a beneficial effect on the recovery of each fish species population there would be a lower commercial effort (i.e. trips by boats) and lower landings (catch in pounds) after the “net ban” took effect.

As can be seen from Figure 1, after the “net ban” became effective, the average for the annual number of commercial fishing trips for all species was less than half of the number of trips (i.e. a 55% reduction comparing the 1992-1994 data to the 1997-1999 data) prior to the “net ban.” The number of trips for some species had been reduced by as much as 70 to 90% (e.g. menhaden – 73% reduction; shad – 97% reduction; see Figure 2). Figure 3 shows that the landings (in pounds of fish) were reduced by an annual average of 68% for all species. The reduced landings for some species were significantly higher than that (e.g. spotted weakfish – 82% reduction; spotted sea trout – 91% reduction; see Figure 4). The numerical data for Figures 1 - 4 are presented in Table 1.

By 2001-2003, the average annual number of trips had been reduced by over 60% from the pre-net ban trips, and the average annual landings had been reduced by two-thirds compared to the pre-net ban landings (see Figures 1 and 3).

It should be noted that not all reductions were due solely to the elimination of gill nets from inshore waters. Some species experienced additional restrictions even after the imposition of the “net ban.” Specifically: (1) the commercial fishing season for the spotted sea trout was reduced to June through August and the minimum size was raised to 15 inches; (2) the minimum size for the weakfish was increased to 12 inches; (3) the commercial shad fishery was closed; and (4) additional regulations regarding offshore gillnetting of pompano resulted in fewer trips in 1997-1999, but increased landings in those years as the fishery moved into federal waters where entangling gear is still permitted.

¹ Memorandum from Robert Muller dated October 11, 2000 regarding the “Effects of the constitutional amendment to eliminate entangling gears in state waters.”

² Memorandum from Robert Muller dated June 15, 2004 regarding “Updating an analysis evaluating the effects of the constitutional amendment to eliminate entangling gears in state waters.”

Fig. 1--Annual average statewide commercial fishing trips for all net caught species

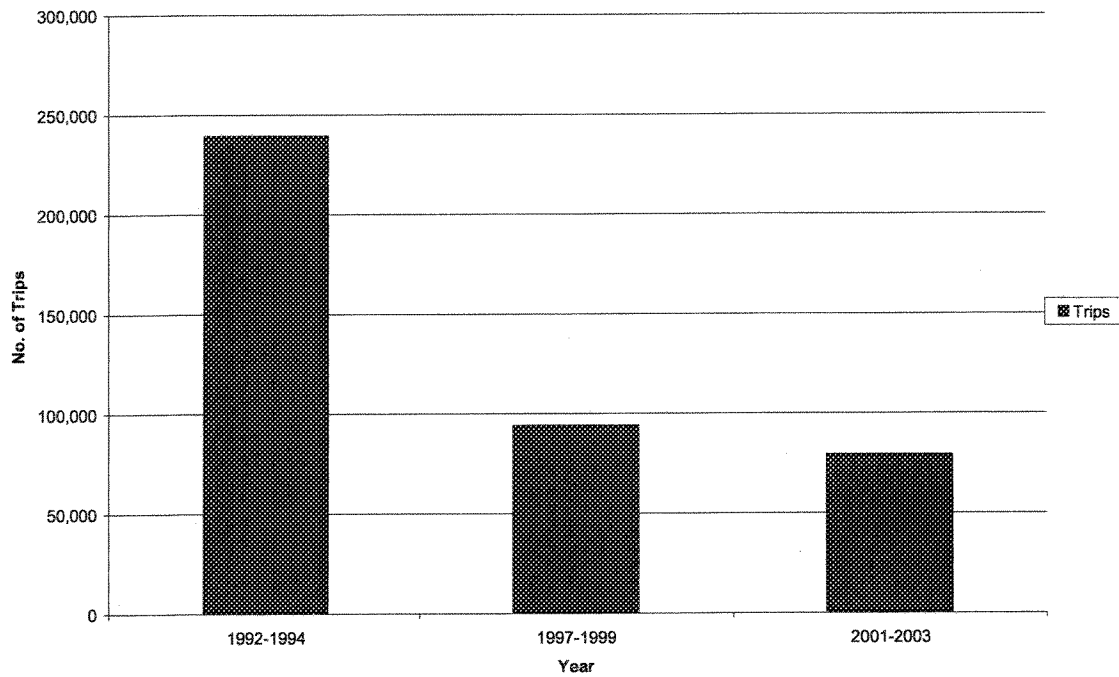


Fig. 2--Annual average statewide commercial fishing trips for net caught species

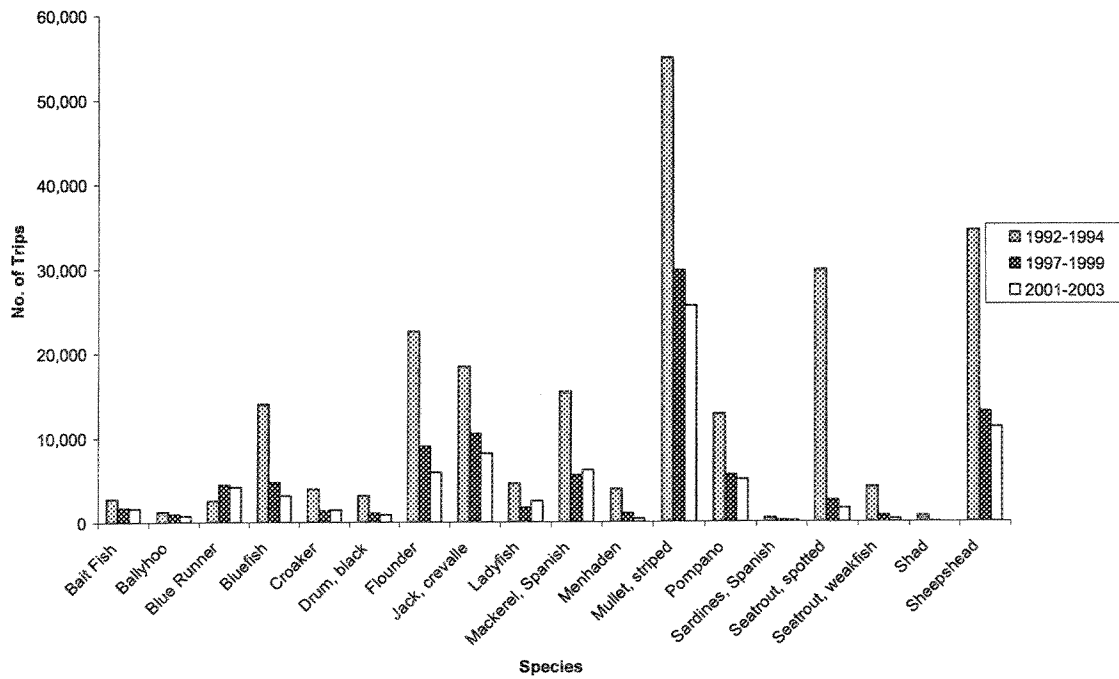


Fig. 3--Annual average statewide commercial landings (in pounds) for all net caught species

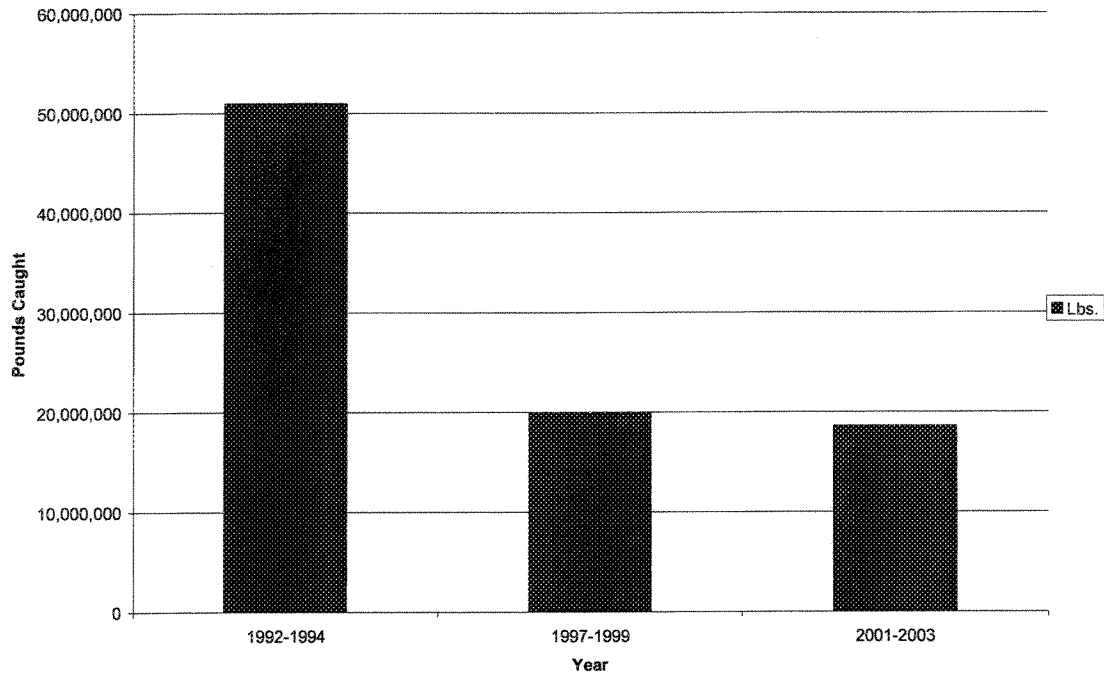
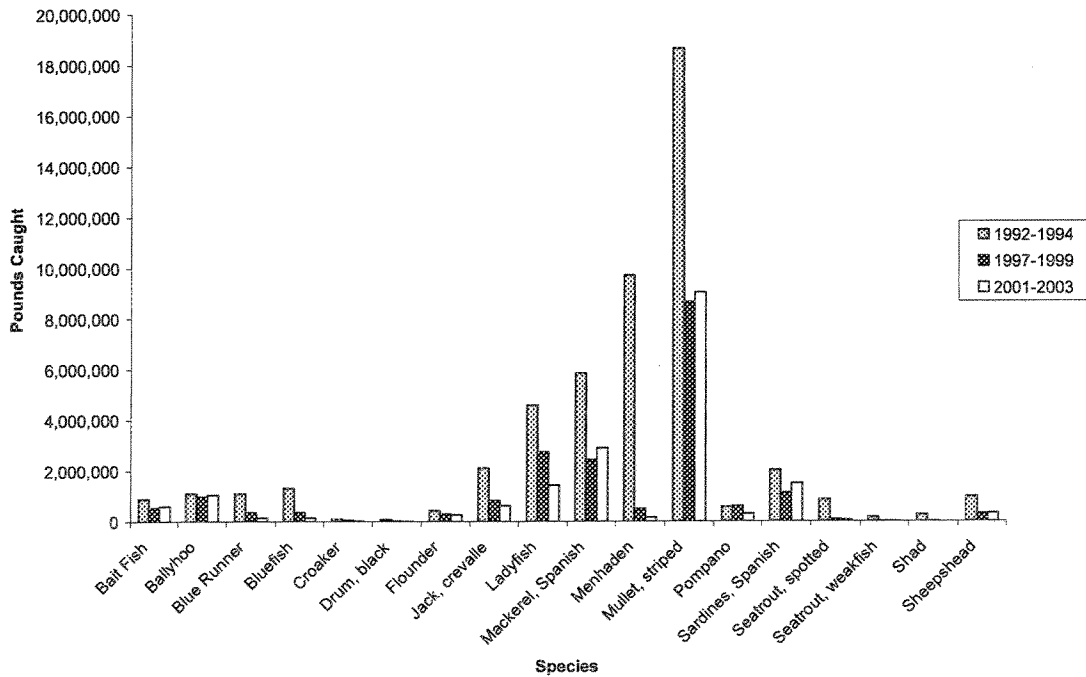


Fig. 4--Annual average statewide commercial landings (in pounds) for net caught species



If the success of the “net ban” can be measured in terms of reductions in commercial fishing trips and landings then the dramatic reductions in these criteria from pre-net ban years to the most recent post-net ban years would seem to indicate that the “net ban” amendment has successfully accomplished its intended purpose.

Changes in Fish Stocks

Another method for measuring the recovery of fish stocks is the *spawning potential ratio* (SPR). The SPR is defined as the number of eggs that could be produced by an average female fish in the current fished stock divided by the same number for an unfished stock. Theoretically, a reduction in the fishing effort would allow more female fish to produce eggs, thereby increasing the overall health of the fish stock.³

Looking at the most heavily fished species, and utilizing the SPR, it appeared that the stocks of *striped mullet* were increasing as early as 1998 and by 2000 it was no longer considered to be overfished. Likewise, by 2000 *Spanish mackerel* was no longer considered to be overfished. *Sheepshead* stocks have been increasing since 1994 and recent data from 2000 demonstrate that they are no longer considered overfished. However, the *spotted sea trout* is still considered to be overfished except in the northeast region of the state. Recent data from 2002 shows that overfishing continues to occur for the *bluefish* even though populations have shown an increase since 1993. Similarly, *pompano* are still considered overfished even though stocks are increasing. There are no formal stock assessments for the *crevalle jack*, *flounder*, *ladyfish*, *menhaden*, or *Spanish sardine*.⁴ See Appendix A for assessments on each species.

Commercial vs. Recreational

The results of recent research looking at the impacts of recreational marine fishing nationwide show that there has been a significant increase in recreational fishing effort over the past 20 years. With public attention focused on the impacts of commercial fishing on fish stock depletion, bycatch and habitat damage, little attention was paid to the impacts of the recreational sector.⁵

While nationwide the recreational catch only comprises 4-5% of the total catch, in certain regions of the coastal U.S. the recreational catch makes up a significantly higher percent of the total catch. In the Gulf of Mexico, the recreational catch accounts for almost two-thirds the total catch (64%), and in the South Atlantic the recreational catch makes up 38% of the total catch.

In Florida, it is estimated that in 2001 recreational fishermen accounted for 88% of landings (by weight) for bluefish, 75% for crevalle jack, 69% for pompano, 68% for flounder, 15% for ladyfish, 55% for menhaden, 98% for spotted seatrout, 90% for sheepshead, and 59% for Spanish mackerel. Striped mullet and Spanish sardines are almost exclusively commercial fisheries.

³ "What Happened After the Net Ban?", Chuck Adams, Steve Jacobs, and Suzanna Smith, Food and Resources Economics Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, February 2000, Publication No. FE 123

⁴ Fish and Wildlife Research Institute, Status and Trends 2002 Report – Florida's Inshore and Nearshore Species, Species Account – Finfish, <http://research.myfwc.com/features>.

⁵ "The Impact of United States Recreational Fisheries on Marine Populations," Felicia Coleman et al., in Science Express, August 26, 2004

II. IMPACTS ON THE COMMERCIAL FISHING INDUSTRY

The commercial seafood industry represents an important component of Florida's economy and its cultural heritage. Seafood production contributes over \$1 billion to the state's economy. Moreover, commercial seafood production is a way of life for many families in coastal communities around the state. Commercial fishing is tied not only to the personal identity of the fishing families and the identity of the fishing community, but also to the state's historical and cultural roots.⁶

Even before the net ban, rapid population growth along with an increase in seasonal residents and tourists along Florida's coastal areas had already displaced many commercial fishing operations from working waterfronts.⁷ Those commercial fishing operations that survive struggle to maintain their commercial working waterfronts in the face of growing residential and tourism development and increasingly strict management of commercial fishing.⁸ Because the number of commercial fishermen has been decreasing, they often lose their voice in local government decisions and in fisheries management decisions – decisions that now threaten to dislodge them from their traditional roles.⁹

Some have observed that “to fully understand the magnitude of Florida's net ban, a clearer understanding of the social implication must be attained. The net ban had the potential to damage fishing families by eliminating their primary source of income, their family business, and a central part of their identity, as well as the potential to disrupt entire communities that were dependent on commercial seafood production as a significant part of their economic base.”¹⁰

The implementation of the net ban forced an estimated 1,500 families living in Florida's coastal communities to either alter their fishing gear or leave the commercial fishing industry.¹¹ While no comprehensive study was conducted to measure the impact of the net ban on the commercial fishing industry, Florida Sea Grant-funded research followed a group of 44 commercial fishing families before and after the net ban. The families were first interviewed before the net ban during 1991-1993 as part of an earlier study. A subset of the first group of families was interviewed again as part of another study during 1997-1998. A comparison of the results of the interviews allows a comparison of fishing family business activities before and after the net ban. This is the only statewide assessment of the net ban impacts on Florida fishing families.¹²

⁶ “*The Impacts of the Florida Net Ban on Commercial Fishing Families*,” Suzanna Smith et al., Technical Report No. 101, Florida Sea Grant College Program. University of Florida, Gainesville; p. 1.

⁷ “*The Impact of Tourism on a Natural Resource Community: Cultural Resistance in Cortez, Florida*,” Michael Jepson, Doctoral dissertation, University of Florida, 2004, unpublished, p. 2.

⁸ Ibid. p. 44.

⁹ Ibid. p. 50.

¹⁰ “*The Impacts of the Florida Net Ban on Commercial Fishing Families*,” p. 2.

¹¹ “*What Happened After the Net Ban?*,” Chuck Adams, Steve Jacobs, and Suzanna Smith, Food and Resources Economics Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, February 2000, Publication No. FE 123, p. 4

¹² Ibid. p. 3.

A comparison of the “before and after” time periods shows that three-quarters of the families were still engaged in commercial fishing after the net ban. However, only 70% of those were fishing full-time compared to 90% fishing full-time before the net ban. One quarter of those interviewed had retired completely from commercial fishing.¹³

The percentage of family income from fishing had decreased from 80% to only 50%. These families were far more dependent on income derived primarily from the wives of the fishermen working in nonfishing employment. The amount of time devoted by husbands to nonfishing work increased from 6 hours per week to 12 hours per week.¹⁴

Fishermen reported that the amount of time spent operating a commercial fishing boat dropped from 62 hours per week to 38 hours per week. The time spent on sales and marketing increased from one hour per week to five hours per week.¹⁵

The net ban also caused changes in the species targeted by those who remained in the business. The more notable changes are:

- ❖ The number of fisherman targeting mullet decreased from 91% to 67%
- ❖ The number of fisherman targeting sea trout decreased from 41% to 9%
- ❖ The number of fisherman targeting pompano decreased from 50% to 18%
- ❖ The number of fisherman targeting stone crab increased from 9% to 36%
- ❖ The number of fisherman targeting grouper increased from 7% to 15%¹⁶

In order to soften the impact of the net ban, Florida offered several assistance programs to commercial fishing families including a net buy back program, unemployment compensation, job retraining and assistance through the Florida Cooperative Extension Service. However, while these program were of some help to the affected families, they did not fully meet their needs. Those interviewed reported that this failure was in large part due to a lack of coordination between the participating agencies.¹⁷

¹³ Ibid. at p. 4

¹⁴ Id.

¹⁵ Id.

¹⁶ Id.

¹⁷ “The Impacts of the Florida Net Ban on Commercial Fishing Families”, p. 20-23.

SUMMARY

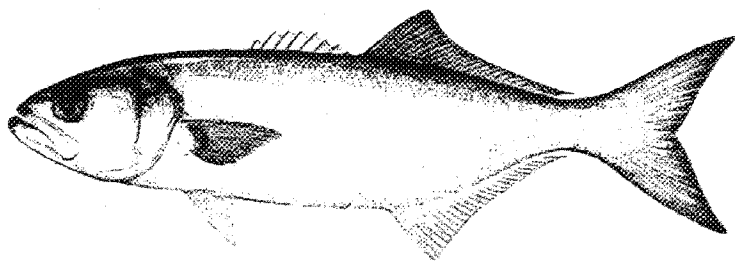
The purpose of the Net Ban Amendment was primarily to protect saltwater finfish from overfishing. Based on the available data, it appears that for certain selected species, most notably striped mullet, sheepshead and Spanish mackerel, that purpose has been accomplished. There is as yet insufficient data to determine whether any other species are still overfished.

There is growing evidence that recreational fishing is having an increasing impact on fish stocks relative to the impacts from commercial fishing. Therefore, any future effort to assess the impacts of fishing on fish stocks should include the impacts from recreational fishing.

Finally, it must be acknowledged that any success of the net ban in reducing overfishing has come with a significant negative impact on the commercial fishing interests in Florida. The greatest impacts have been the economic and social impacts experienced by commercial fishing families and local coastal fishing communities.

APPENDIX A

Bluefish, *Pomatomus saltatrix*



Bluefish are a schooling, migratory pelagic species that occur seasonally in Florida's inshore and continental shelf waters. In the western Atlantic, bluefish range from Nova Scotia, Canada, along the Atlantic coast of the U.S. to Cuba's northwest coast, throughout the Gulf of Mexico, and along the South American coast from Colombia to Argentina. Tagging and mtDNA analyses show that sufficient mixing occurs between the U.S. gulf and Atlantic coast bluefish populations to maintain a single genetic stock (Miller 1969, Graves *et al.* 1992a); although, mixing may be limited enough to consider the two groups as separate fishery stocks. Bluefish grow rapidly in their first year of life and achieve a size of 32" fork length (FL) in about 10 years. The maximum age reached by bluefish appears to be about 11 years. Bluefish reach sexual maturity before age 2. Spawning occurs during April and May near the inner reaches of the Gulf Stream off Florida's Atlantic coast and during April and October–November in the northern Gulf of Mexico.

Table 1. Von Bertalanffy growth parameters and length-weight relations for bluefish

Inches FL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Combined (gulf)	0.18	37.2	-1.033	Barger (1990)
Combined (Atlantic)	0.096	40.1	-2.493	Barger (1990)
Weight in lbs = $a(\text{inches FL})^b$	a	b	Source	
Combined (Florida)	0.000411	3.064	FWC-FMRI Unpublished data	

Bluefish are opportunistic feeders whose food reflects prey availability and prey preference, especially as it relates to the size of the bluefish (Naughton and Saloman 1984). Schools of bluefish can be located at a distance by looking for hovering seagulls that are eating forage fish driven to the surface by feeding bluefish (Olla *et al.* 1970). Presumably, larvae and juveniles eat zooplankton (Kendall and Walford 1979). The food of young-of-the-year bluefish includes small shrimp, anchovies, killifish, silversides, and crabs (Pottern *et al.* 1989). In the Gulf of Mexico and off the southeastern U.S., adults prey heavily on schooling fishes such as Atlantic croaker, striped mullet, menhaden, Spanish sardine, Atlantic bumper, and round scad. Invertebrate prey includes portunid crabs, penaeid shrimp, squid, and gastropods. The trophic impacts of bluefish feeding have been investigated for U.S. Atlantic coast waters (Buckel *et al.* 1999a, 1999b). The prey biomass consumed by bluefish was about eight times the biomass of the bluefish population (Buckel *et al.* 1999b). Estimated annual consumed biomass of butterfish, *Peprilus triacanthus*; long-finned squid, *Loligo pealei*; and boreal squid, *Illex illecebrosus*, was much higher than that harvested by the commercial fisheries for these species during 1982–1994.

Bluefish consumption of menhaden, *Brevoortia tyrannus*, was less than the fisheries landings. In the waters north of Cape Hatteras, predation on bay anchovies, *Anchoa mitchilli*, was 2.2–6.8 billion fish during the month of September in each of 1994 and 1995 (Buckel *et al.* 1999a).

Statewide landings of bluefish were 1,377,635 pounds in 2001. These landings were made mostly by recreational fishers (88% of statewide landings by weight) and mostly on the Atlantic coast (62% of statewide total). During 2001, commercial landings greater than 50,000 pounds were reported from Brevard, Indian River, and Martin counties on the Atlantic coast and Collier and Monroe counties on the gulf coast of Florida (Fig. 1). Landings made by the recreational fishery were greatest in the northeast and east-central regions and in the northwest coast of Florida (Fig. 2). The 2001 total landings were 45% higher than the average landings in the previous five years (1996–2000) and were 51% lower than the historical average landings of 1982–2001 (Fig. 3). On the Atlantic coast, total annual landings of bluefish fluctuated during 1982–1993 and declined from 2.47 million pounds in 1993 to about 0.85 million pounds in 2001 (Fig. 3). Total annual landings on the gulf coast fluctuated without trend through 1991 then declined to 0.1–0.5 million pounds during 1994–2001.

From 1986 to 1993 commercial catch rates on the Atlantic coast fluctuated without trend at approximately 10 pounds per trip. From 1993 through 1996, commercial catch rates on the Atlantic coast declined reaching their lowest level since 1986. The declining catch rates during this period probably reflect the trip limits imposed on the Atlantic coast fishery in July 1993. Since 1996, the commercial catch rate has increased, reaching a high in 1999 followed by a decline in 2000 and 2001 (Fig. 4). On the gulf coast, the commercial catch rate exhibits a cyclical trend around 15 pounds per trip with peaks occurring in 1989, 1992, 1995, and 2000 (Fig. 5). On the Atlantic coast, total-catch rates for anglers have steadily increased since 1982 (Fig. 6). Catch rates for anglers in the gulf appear steady at just under two fish per trip since 1993 (Fig. 7).

The most recent assessment of the bluefish stock on the U.S. Atlantic coast indicates that the stock is overfished but is rebuilding (ASMFC 2002a). Stock biomass declined from a peak level of 202 million pounds in 1981 to 32 million pounds in 1995 (ASMFC 2002a). Since 1995, the total stock biomass increased to 86.5 million pounds in 2001 (73% of the biomass threshold relative to ASMFC Amendment 1 overfishing definitions). The fishing mortality rates for bluefish peaked in 1991 at 0.76 per year and have since declined to 0.25 per year in 2001; fishing mortality rates were below the target of 0.41 per year for 2002 and 2003 (ASMFC 2002a). The Atlantic States Marine Fisheries Commission has established a fishery management plan for bluefish that requires size limits, bag-limits (or conservation equivalencies), and commercial quotas. Florida, first judged in compliance with these requirements in 1995, established a commercial quota of 877,000 pounds for the Atlantic coast beginning in the 1996 calendar year. Florida's Atlantic coast commercial landings were only about 134,000 pounds in 1996 and 284,000 pounds in 1997, well below the quota allocation. The most recent assessment of bluefish on the Atlantic coast of Florida (De Silva 2002) indicates that the population has shown an increase after the implementation of size- and bag-limit regulations in 1993. The population has been relatively stable, at around 4.8 million fish, since 1994. From 1994 to the present, recruitment into the fishery has been relatively stable; approximately 2.2 million recruits enter the fishery each year. Fishing mortality rates indicate a steady decline since 1981. From 1996 to the present, the annual fishing mortality rate has been stable at approximately 0.16 per year. On the gulf, a recent assessment (Heinemann 2002) concluded that biomass levels were between 0.12 and 0.26 of the B_{MSY} , and that overfishing continues to occur.

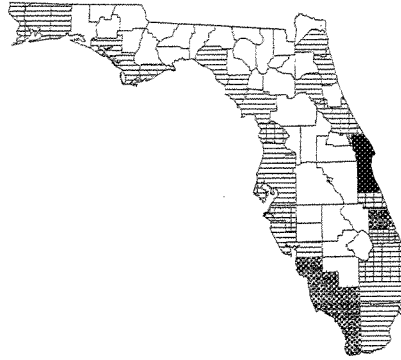


Figure 1. Geographic distribution of commercial landings of bluefish during 2001

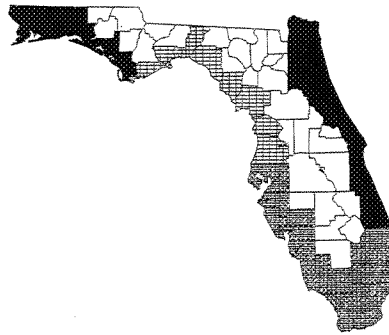


Figure 2. Geographic distribution of recreational landings of bluefish during 2001

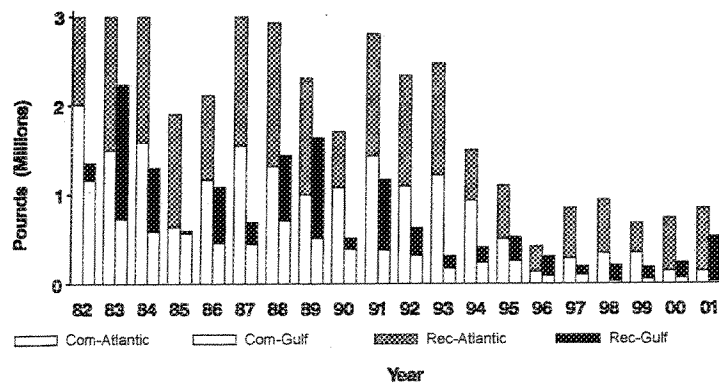


Figure 3. Total landings of bluefish on the Atlantic and gulf coasts of Florida, 1982–2001

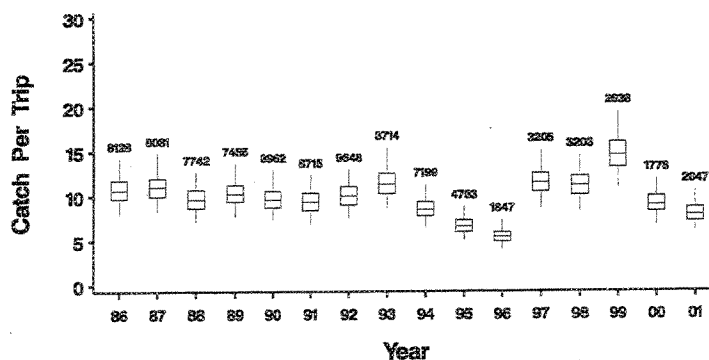


Figure 4. Annual standardized commercial catch rates (pounds) for bluefish on the Atlantic coast of Florida, 1986–2001

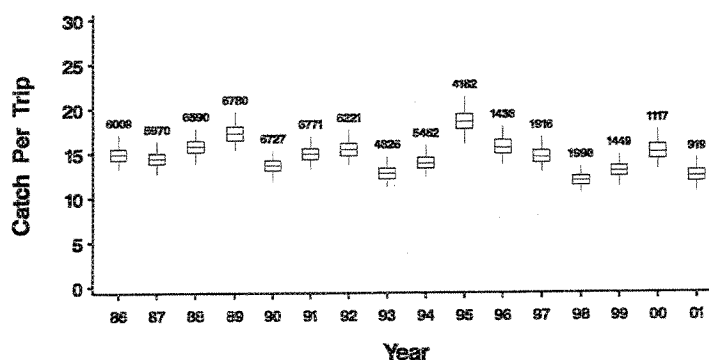


Figure 5. Annual standardized commercial catch rates (pounds) for bluefish on the gulf coast of Florida, 1986–2001

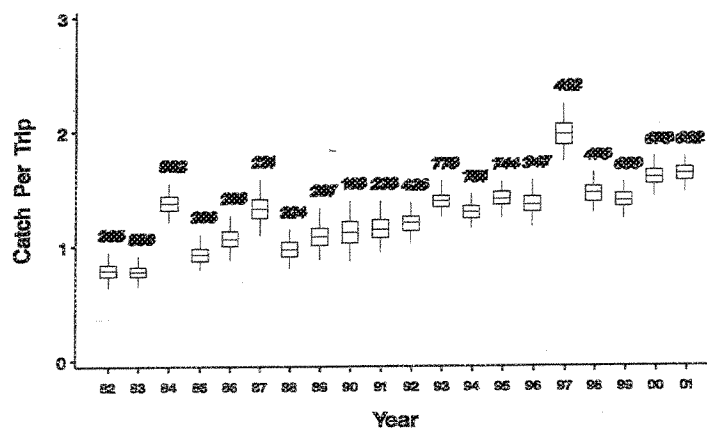


Figure 6. Annual standardized recreational total-catch rates (numbers) for bluefish on the Atlantic coast of Florida, 1982–2001

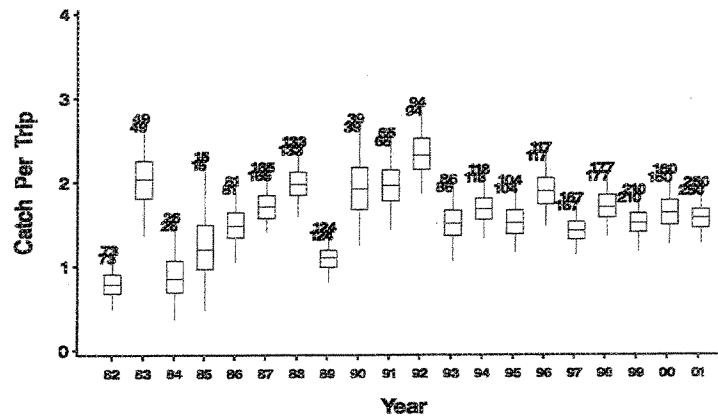
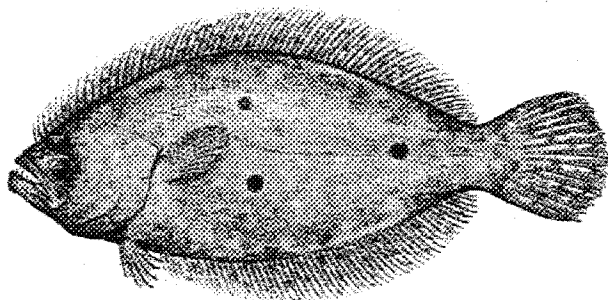


Figure 7. Annual standardized recreational total-catch rates (numbers) for bluefish on the gulf coast of Florida, 1982–2001

Flounders, *Paralichthys* spp.



Nearly all flounders landed by anglers in Florida are one of three species in the genus *Paralichthys*: gulf flounder *P. albigutta*; southern flounder, *P. lethostigma*; or summer flounder, *P. dentatus*. Gulf flounder are the only species to range along the entire Florida coast. Summer flounder are only a minor component of the flounder landings in northeast Florida; their center of distribution is off the U.S. Mid-Atlantic Bight. Southern flounder are generally only found north of the Loxahatchee River on the Atlantic coast and north of the Caloosahatchee River on the gulf coast. The distributions of gulf and southern flounder appear to be substrate-related. Southern flounder are found on silt and mud, and gulf flounder are found mostly on sand. Studies have shown that female southern flounder reach about 28" and 7 years of age while female gulf flounder reach only about 18" and 3 years of age (Wenner *et al.* 1990; Stokes 1977). More recently, Fitzhugh *et al.* (1999) reported that gulf flounder attain older ages than previously thought: the oldest gulf flounder found in offshore waters off northwest Florida was age 11. While estuarine samples of southern flounder show maximum ages of about 4 years (Stunz *et al.* 2000; Fitzhugh *et al.* 1999), older fish probably occur in shelf waters. Males of both species do not get as large as females. Female southern flounder mature at age 3 or 4 (Wenner *et al.* 1990), and female gulf flounder mature at age 1 (Fitzhugh *et al.* 1999). Both species spawn in offshore waters during late fall–winter (65 ft–200 ft).

Table 1. Von Bertalanffy growth parameters and length-weight relations for flounders

Inches TL = $L_{\infty}(1 - e^{-K(\text{age} - t_0)})$	K	L_{∞} (inches TL)	t_0 (years)	Source
Male southern flounder, South Carolina	0.25	20.4	-1.07	Wenner <i>et al.</i> (1990)
Female southern flounder, South Carolina	0.23	29.9	-0.57	Wenner <i>et al.</i> (1990)
Male gulf flounder, northwest Florida	0.60	13.6	-2.4	Fitzhugh <i>et al.</i> (1999)
Female gulf flounder, northwest Florida	0.40	19.4	-2.14	Fitzhugh <i>et al.</i> (1999)
Male southern flounder, northwest Florida	0.32	13.5	-5.2	Fitzhugh <i>et al.</i> (1999)
Female southern flounder, northwest Florida	1.67	18.0	-0.75	Fitzhugh <i>et al.</i> (1999)

Weight in lbs = $a(\text{inches TL})^b$	a	b	Source
Male southern flounder, South Carolina	0.000261	3.17	Wenner <i>et al.</i> (1990)
Female southern flounder, South Carolina	0.000275	3.15	Wenner <i>et al.</i> (1990)
Male gulf flounder, northwest Florida	0.000579	2.81	Fitzhugh <i>et al.</i> (1999)

Weight in lbs = a (inches TL) ^b	a	b	Source
Female gulf flounder, northwest Florida	0.000220	3.2183	Fitzhugh <i>et al.</i> (1999)
Male southern flounder, northwest Florida	0.000906	2.5723	Fitzhugh <i>et al.</i> (1999)
Female southern flounder, northwest Florida	0.000200	3.314	Fitzhugh <i>et al.</i> (1999)

Gulf flounders are benthic carnivores. Large juveniles feed primarily on small fish and crustaceans (shrimp and crabs). Adults feed on schooling fish such as menhaden, bay anchovy, pinfish, grunts, pigfish, Atlantic croaker, and mullets (Springer and Woodburn 1960; Topp and Hoff 1972; Benson 1982).

Total landings of flounders in Florida during 2001 were 825,662 pounds, the majority of which (68%) were landed by the recreational fishery. Landings were slightly greater on the Atlantic coast, where about 52% of the statewide landings were made in 2001. In 2001, commercial landings on the Atlantic coast were highest in Volusia County (Fig. 1). On the gulf coast, commercial landings were greatest in Escambia, Bay, and Franklin counties. Estimated recreational landings of flounders on the Atlantic coast were highest in the waters between Volusia and Martin counties (Fig. 2). On the gulf coast, recreational landings were highest in the southwest region from Pinellas to Monroe counties.

In Florida, total annual landings of flounders have declined since 1982 (Fig. 3). The 2001 total landings of flounders were 5% lower than the average landings in the previous five years (1996–2000) and were 22% lower than the historical average landings (1982–2001). In 1995, Atlantic coast recreational landings were almost exclusively southern flounder, while gulf coast recreational landings were mostly gulf flounder. Based on limited commercial sampling, the species composition of the commercial landings appears to be similar to that of the recreational landings (Murphy *et al.* 1994).

Annual standardized commercial catch rates for mixed flounder species on the Atlantic and gulf coasts have increased since 1996 (Figs. 4, 5). Recreational catch rates for gulf flounder are much lower on the Atlantic coast than on the gulf coast (Figs. 6, 7). No apparent trends were detectable on either coast. Standardized recreational total-catch rates for southern flounder on the Atlantic coast were relatively stable between 1989 and 1994, increased through 1997, and exhibited an annual decline until 2001 (Fig. 8). Gulf coast catch rates for anglers fishing for southern flounder declined markedly between 1982 and 1989, but catch rates have remained relatively stable and low through 2001 (Fig. 9).

Highly variable standardized juvenile indices from both the Atlantic and gulf coasts occasionally peaked through 1998; thereafter, they dramatically dropped (Figs. 10,11).

Murphy *et al.* (1994) found that adequate information was not available to assess the condition of southern or gulf flounder stocks in Florida. A rough characterization of gulf flounder's population dynamics suggested it was unlikely that they were being fished at a maximum level of yield-per-recruit. Summer and southern flounder populations, which mature at a larger size and older age, are possibly more sensitive to fishing than gulf flounder. New life history information (Fitzhugh *et al.* 1999) needs to be considered in future assessments of gulf or southern flounder.

Assessments of the status of summer flounder in North Carolina northward found that the stock abundance in 1993–1994 was at the lowest average level since the 1960s. Although data indicated that 1993 year-class was very poor, some stock rebuilding had occurred due to good recruitment in 1991 and 1992. The Atlantic States Marine Fisheries Commission (1982)

developed a Fishery Management Plan for summer flounder for the stock north of North Carolina.

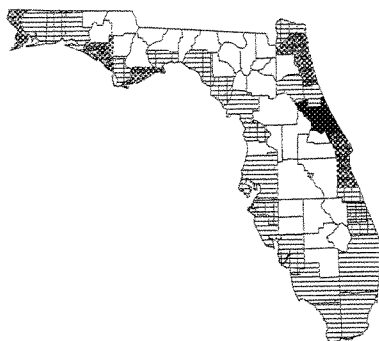


Figure 1. Geographic distribution of commercial landings of flounder during 2001

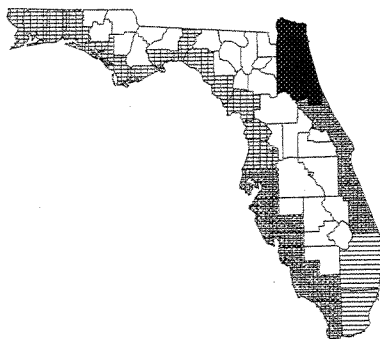


Figure 2. Geographic distribution of recreational landings of flounders during 2001

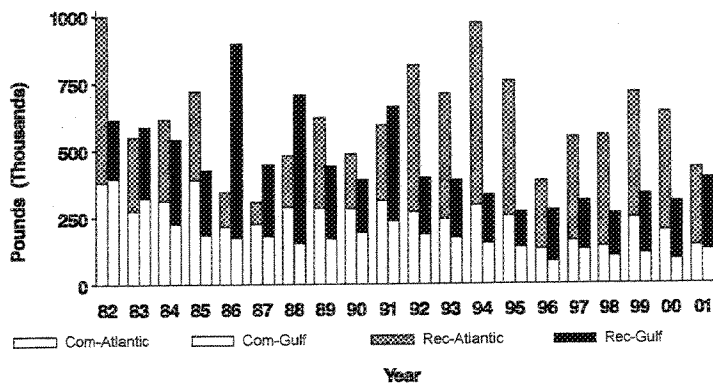


Figure 3. Total annual landings of flounders (paralichthids) on the Atlantic and gulf coasts of Florida, 1982–2001

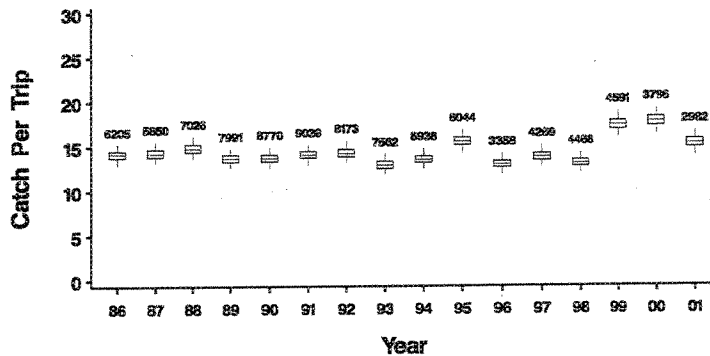


Figure 4. Annual standardized commercial catch rates (pounds) for flounders on the Atlantic coast of Florida, 1986–2001

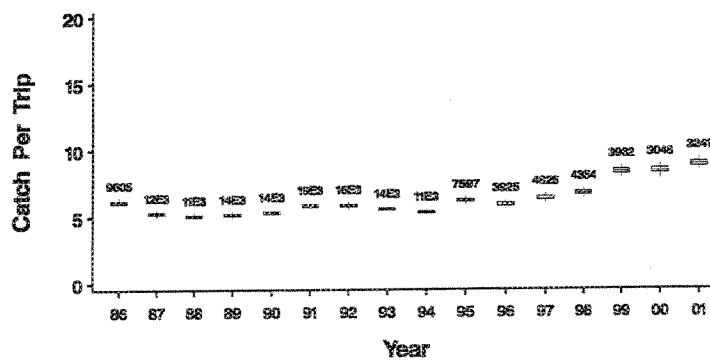


Figure 5. Annual standardized commercial catch rates (pounds) for flounders on the gulf coast of Florida, 1986–2001

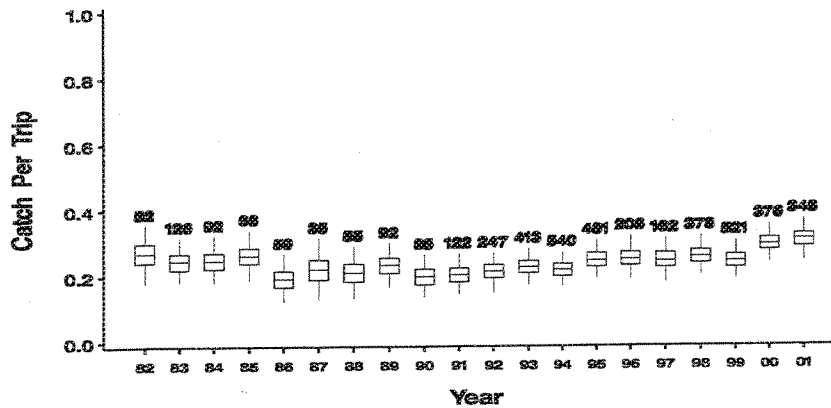


Figure 6. Annual standardized recreational total-catch rates (numbers) for gulf flounder on the Atlantic coast of Florida, 1982–2001

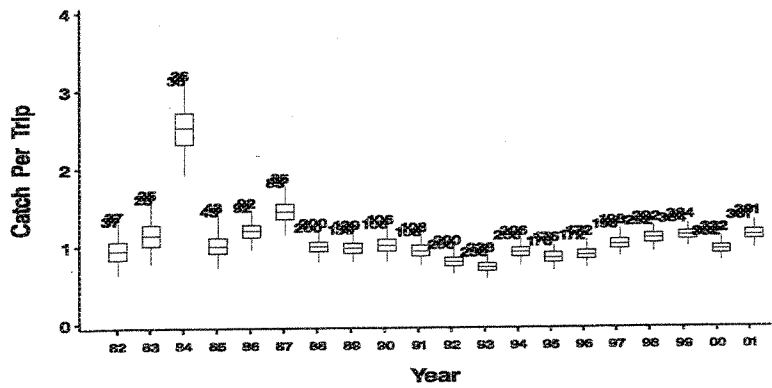


Figure 7. Annual standardized recreational total-catch rates (numbers) for gulf flounder on the gulf coast of Florida, 1982–2001

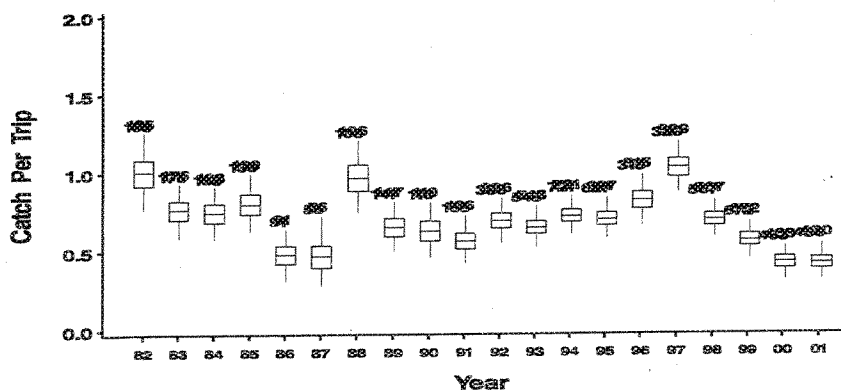


Figure 8. Annual standardized recreational total-catch rates (numbers) for southern flounder on the Atlantic coast, 1982–2001

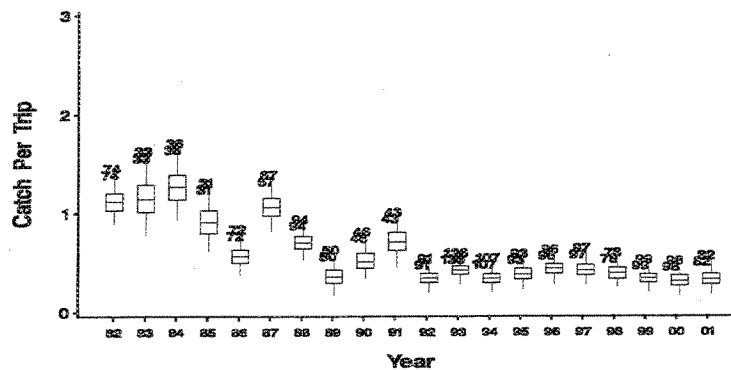


Figure 9. Annual standardized recreational total-catch rates (numbers) for southern flounder on the gulf coast of Florida, 1982–2001

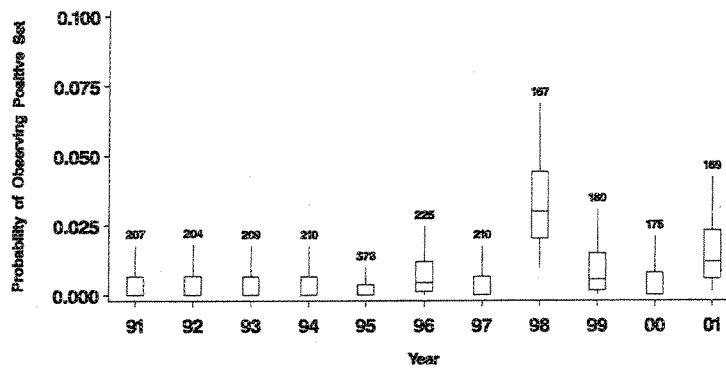


Figure 10. Percentage of Fishery-Independent Monitoring sets that captured young-of-the-year gulf flounder on the Atlantic coast, 1991–2001

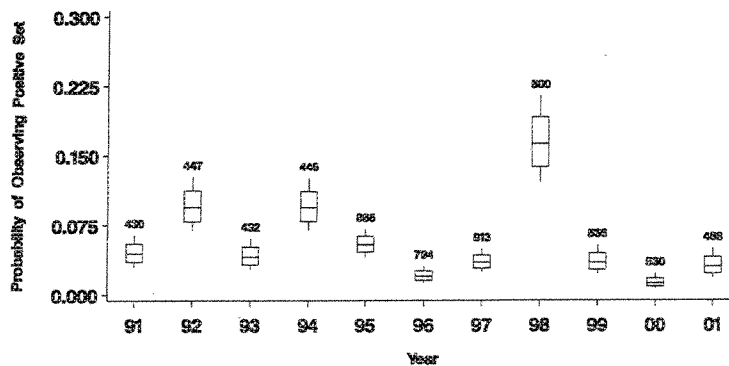
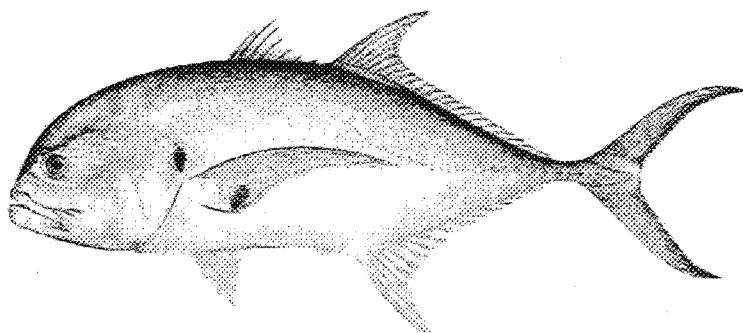


Figure 11. Percentage of Fishery Independent Monitoring sets that captured young-of-the-year gulf flounder on the gulf coast, 1991–2001

Crevalle jack, *Caranx hippos*



Crevalle jack are found throughout the Gulf of Mexico and southern U.S. East Coast across a wide range of depths from shallow inshore to oceanic waters (Benson 1982). Except for the development and ecology of juveniles, little is known about their life history (Berry 1959; McBride 1995). Larvae and early juveniles are pelagic; they are found, occasionally in association with jellyfish, in offshore waters. From April through November, juveniles and small adults inhabit estuaries that exhibit moderate to high salinities (Springer and Woodburn 1960). Occasionally, adults occur in estuaries, but they are more often found on the continental shelf. Crevalle jack reach about 7.9 inches fork length after one year. Females appear to get older and larger than males. The maximum age observed in Florida was 19 years (Snelson 1992). Few fish greater than age 5 have been collected from Florida. Females mature at age 5 or 6; males mature at age 4 or 5. Spawning apparently occurs during the period April–June.

Table 1. Von Bertalanffy growth parameters and length-weight relations for crevalle jack

Inches FL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Combined sexes	0.2168	38.6	-1.2038	Snelson (1992)

Weight in lbs = $a(\text{inches FL})^b$	a	b	Source
Combined sexes	0.002693	2.7344	Bohnsack and Harper (1988)

Stomach content data of crevalle jack clearly indicate that crevalle jack are a major predator on small schooling fishes in the coastal zone of the Gulf of Mexico and the southern U.S. Atlantic coast (Saloman and Naughton 1984). Small jacks prey mostly on clupeids; medium-sized fish usually eat clupeids and sparids, and large fish consume various clupeids, carangids, and sparids (Saloman and Naughton 1984). Large fish appear to be more opportunistic than smaller ones, but food availability, which changes between sizes, seasons, areas, and years, seems to be a major factor in determining diet. Other food items include gulf menhaden, scaled sardine, anchovies, Spanish sardine, Atlantic bumper, pinfish, Atlantic thread herring, crevalle jack, and Atlantic cutlassfish.

Landings of crevalle jack totaled 2,732,289 pounds in Florida during 2001. The recreational fishery made 75% of the statewide landings. Landings were slightly greater on the gulf coast, where about 58% of the statewide landings were made in 2001. Commercial landings

in 2001 were highest from Volusia through Palm Beach counties on the Atlantic coast and in Citrus, Pinellas, Manatee, Lee, and Collier counties on the gulf coast (Fig. 1). Recreational landings were greatest in the east-central, southeast, southwest, and northwest coasts of Florida (Fig. 2). The 2001 total landings were 18% higher than the average landings in the previous five years (1996–2000) and were 10% lower than the 1982–2001 historical average landings (Fig.3). Total annual landings on the Atlantic coast have fluctuated without trend. The gulf coast total landings declined from an average of 2.55 million pounds annually during 1982–1994 to an average of 1.08 million pounds annually during 1995–2000 (the post Amendment 3 period). A total of 1.6 million pounds of crevalle jack were landed on the gulf coast in 2001.

On the Atlantic coast, commercial catch rates have varied without trend (Fig. 4). In contrast, gulf coast commercial-catch rates increased slowly between 1997 and 2001 (Fig. 5). Recreational catch rates have varied without trend on both coasts over the entire 1982–2001 period (Figs. 6, 7).

There is no formal stock assessment for crevalle jack in Florida.

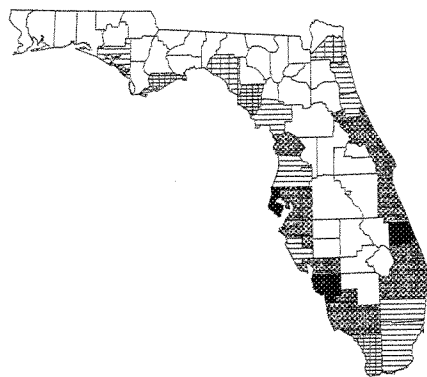


Figure 1. Geographic distribution of commercial landings of crevalle jack during 2001

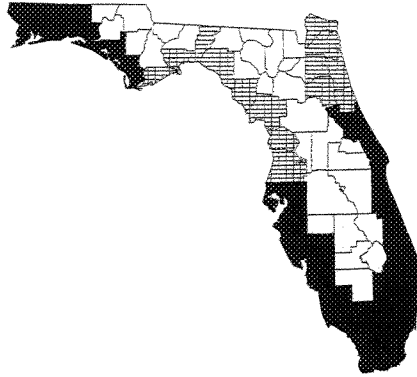


Figure 2. Geographic distribution of recreational landings of crevalle jack during 2001

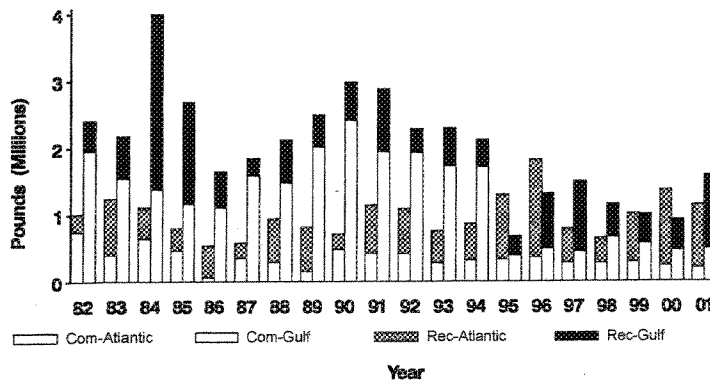


Figure 3. Total annual landings of crevalle jack on the Atlantic and gulf coasts of Florida, 1982–2001

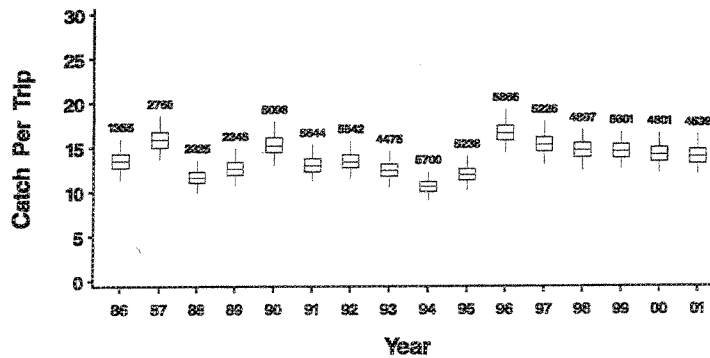


Figure 4. Annual standardized commercial catch rates for crevalle jack on the Atlantic coast of Florida, 1986–2001

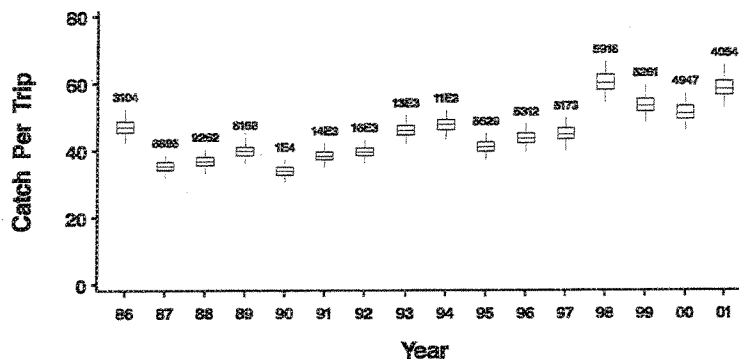


Figure 5. Annual standardized commercial catch rates for crevalle jack on the gulf coast of Florida, 1986–2001

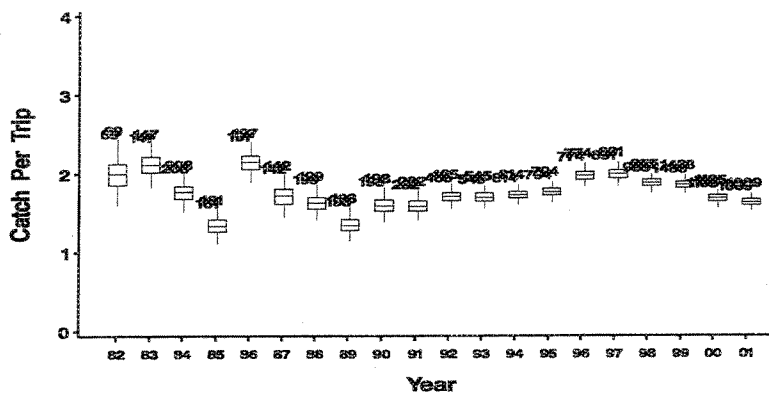


Figure 6. Annual standardized recreational total-catch rates for crevalle jack on the Atlantic coast of Florida, 1982–2001

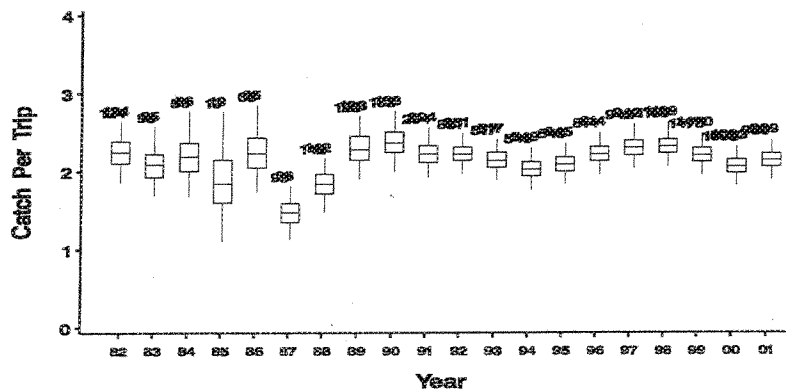
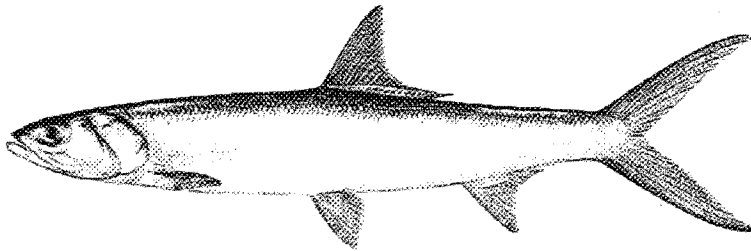


Figure 7. Annual standardized recreational total-catch rates for crevalle jack on the gulf coast of Florida, 1982–2001

Ladyfish, *Elops saurus*



Ladyfish are found throughout Florida's nearshore and estuarine habitats. In the western Atlantic, ladyfish range from southern New England and Bermuda, throughout the Gulf of Mexico, to Rio de Janeiro, Brazil (Bigelow and Schroeder 1953). There may be more than one species or stock of ladyfish in Florida waters: a southern low-myomere-count stock and a northern, high-myomere-count stock (Eldred and Lyons 1966; Smith 1989). Late larval and juvenile ladyfish inhabit coastal beaches, canals, rivers, and mosquito impoundments (Gilmore *et al.* 1981). In general, juveniles seek waters with lower than full-strength salinity: 23 ppt–25 ppt (McBride *et al.* 2001). Adults usually live in coastal or nearshore areas. Length-frequency analysis suggests ladyfish in Tampa Bay grow to 200 mm–300 mm standard length by age 1; by age 2, they reach 300 mm–400 mm, and they are larger than 400 mm by age 3 (McBride *et al.* 2001). Ladyfish that live in hypersaline lagoons in Cuba grow slower, reaching only 247-mm standard length at the time when their third annulus formed (Carles 1967). Ladyfish reach a maximum size of about 39 inches, a weight of about 15 pounds (Zale and Merrifield 1989), and possibly 6 years of age (Palko 1984). Based on the spatial and temporal patterns of collections of early larvae, spawning probably occurs in offshore waters during the fall (Hildebrand 1943).

Table 1. Von Bertalanffy growth parameters and length-weight relations for ladyfish

Inches FL = $L_{\infty}(1 - e^{-K(\text{age} - t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Sex combined, southeast Cuba	0.22	19.2	-0.54	Carles (1967)
Sex combined, Cuba	0.30	18.9		Perez and Rubio (1986)
Weight in lbs = $a(\text{inches FL})^b$	a	b	Source	
Sex combined	0.000302	2.97	Bohnsack and Harper (1988)	

Adult ladyfish feed primarily on fish. Sekavec (1974) found that fish constituted 94% of food items found in ladyfish stomachs; Darnell (1958) also found that fish made up a substantial portion (82%) of the ladyfish diet, and Knapp (1949) found that fish accounted for 34% of food items found in ladyfish stomachs. In Sekavec's study, juvenile gulf menhaden composed 72% of the identifiable fish consumed. Decapod crustaceans are also important foods for ladyfish.

During 2001, the annual commercial landings of ladyfish in Florida were 1,218,039 pounds; most (85%) were landed by the commercial fishery. Landings were greater on the gulf coast, where about 97% of the statewide landings were made in 2001. On the gulf coast, the commercial landings were greatest in Lee, Manatee, Pinellas, and Citrus counties; although,

significant landings occurred in Levy, Gulf, and Bay counties in 2001 (Fig. 1). In 2001, the Atlantic coast commercial fishery landed most of its fish in Brevard County. All these areas were centers of active purse-seine or haul-seine fisheries. The recreational fishery, which landed ladyfish throughout the state, landed a slightly larger number in southwest Florida (Fig. 2)

Florida's 1995 constitutional amendment eliminating the use of entangling nets in state waters severely restricted this fishery. The July 2000 prohibition of the use of tarp nets in the Panhandle region created an additional ladyfish restriction. The 2001 total landings were 44% lower than the average landings in the previous five years (1996–2000) and were 67% lower than the 1982–2001 historical average landings (Fig 3). Total annual landings on the Atlantic coast increased to about 546,000 pounds in 1994 and dropped to about 55,000 pounds in 1997. In 1998, total annual landings on the Atlantic coast increased to nearly 104,000 pounds then dropped to 36,000 pounds in 2001 (Fig. 3). Total annual landings of ladyfish along the gulf coast increased between 1982 and 1990 then declined from a peak of about 5.86 million pounds in 1990 to 1.87 million pounds in 1996. In 1999, gulf coast total annual landings increased to about 4.25 million pounds, sharply declined to 0.4 million pounds in 2000, and increased to 1.2 million pounds in 2001.

Catch rates for the Atlantic coast commercial fisheries have remained at low levels since 1995 (Fig. 4). On the gulf coast, catch rates have gradually increased since 1997 (Fig. 5). Recreational total-catch rates on the Atlantic and gulf coasts varied without a long-term trend during 1982–2001 (Figs. 6, 7).

The indices of abundance for juvenile ladyfish have been highly variable on the Atlantic and gulf coasts (Figs. 8, 9). No long-term (1990–2000) trends were discernable from these data.

No formal stock assessment for ladyfish is available at this time.

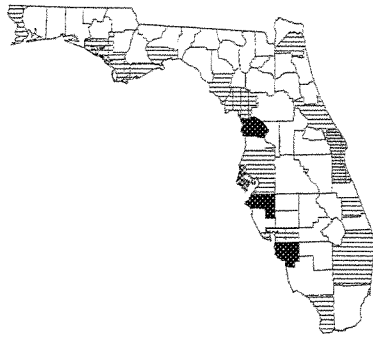


Figure 1. Geographic distribution of commercial landings of ladyfish during 2001

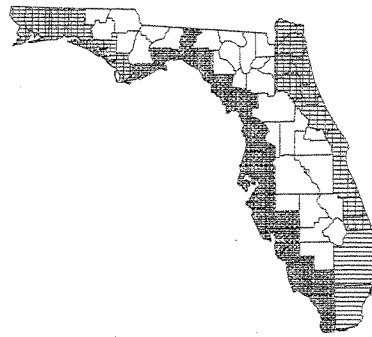


Figure 2. Geographic distribution of recreational landings of ladyfish during 2001

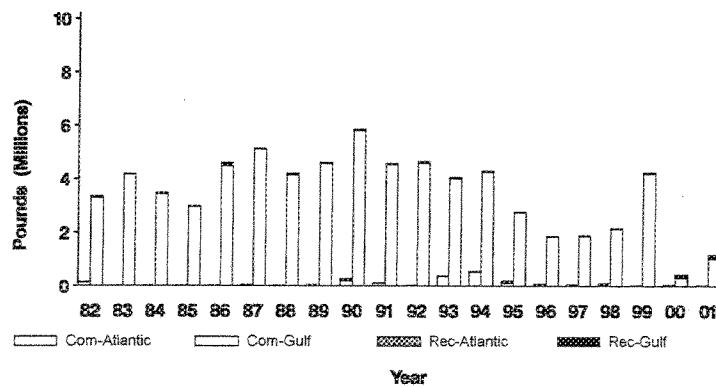


Figure 3. Total annual landings of ladyfish on the Atlantic and gulf coasts of Florida, 1982–2001

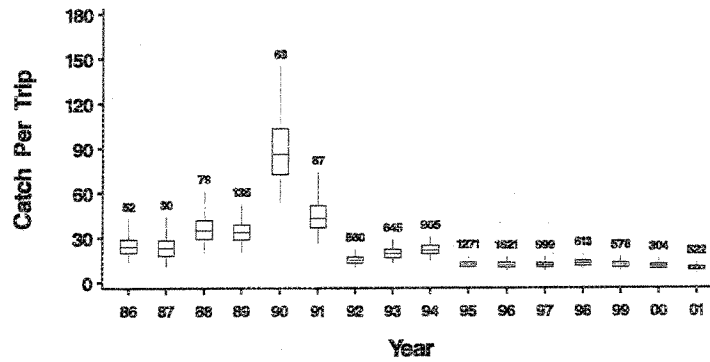


Figure 4. Annual standardized commercial catch rates (pounds) for ladyfish on the Atlantic coast of Florida, 1986–2001

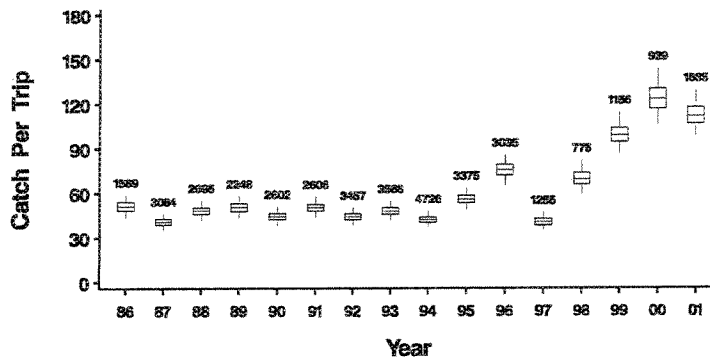


Figure 5. Annual standardized commercial catch rates (pounds) for ladyfish on the gulf coast of Florida, 1986–2001

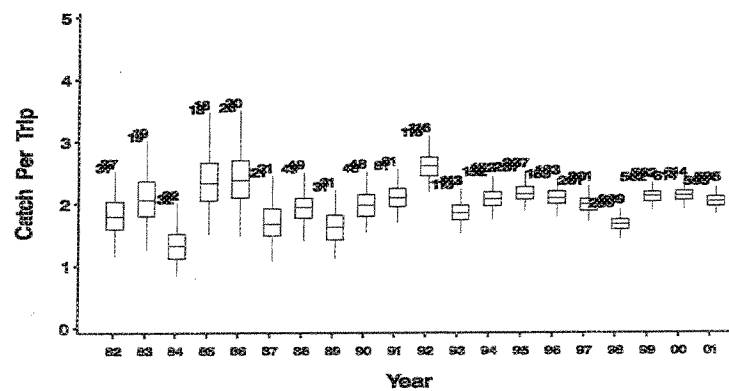


Figure 6. Annual standardized recreational total-catch rates (numbers) for ladyfish on the Atlantic coast of Florida, 1982–2001

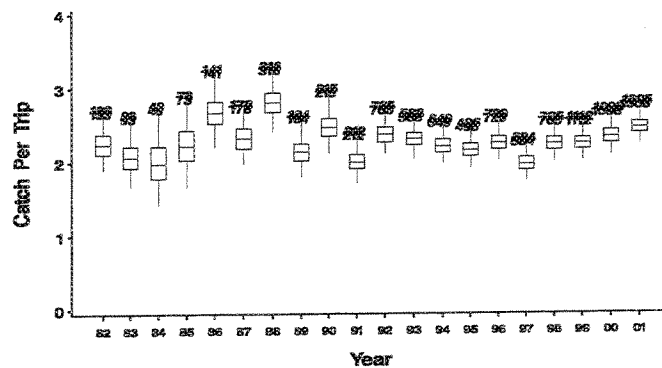


Figure 7. Annual standardized recreational total-catch rates (numbers) for ladyfish on the gulf coast of Florida, 1982–2001

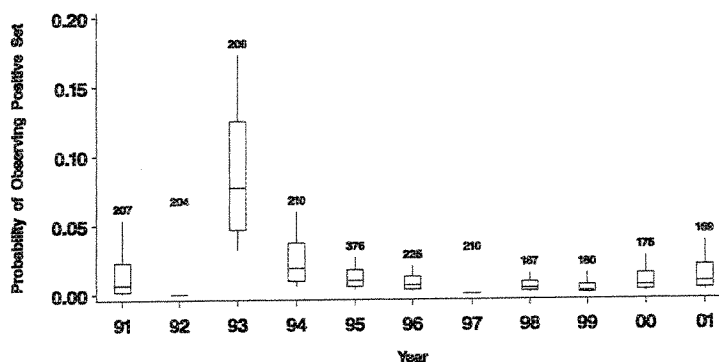


Figure 8. Percentage of Fishery-Independent Monitoring sets that captured young-of-the-year ladyfish on the Atlantic coast, 1991–2001

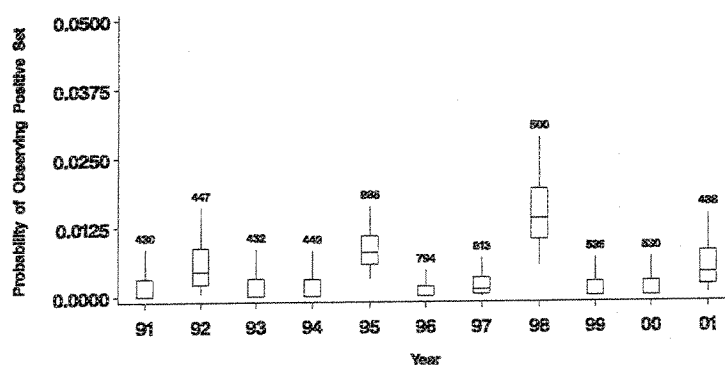
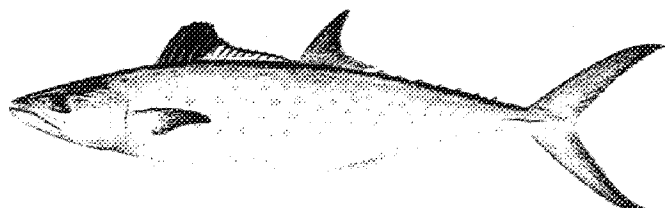


Figure 9. Percentage of Fishery-Independent Monitoring sets that captured young-of-the-year ladyfish on the gulf coast, 1991–2001

Spanish mackerel, *Scomberomorus maculatus*



Spanish mackerel is an epipelagic neritic species that inhabits coastal waters of the western Atlantic Ocean from the Gulf of Maine to Yucatan, Mexico. Depending on water temperature, Spanish mackerel migrate seasonally along the coastline (Collette and Nauen 1983). In the eastern gulf, these fish move northward during late winter and spring, appearing off the central west coast of Florida about April 1 (Moe 1972, Sutherland and Fable 1980). Movement continues westward and terminates along the northern gulf coast. During fall, Spanish mackerel migrate back southward to the wintering grounds in south Florida waters (Moe 1972, Sutherland and Fable 1980). Based on observed patterns of movement and spawning, it appears that one Atlantic and one or more gulf groups of Spanish mackerel occur in Florida waters. Spawning occurs from May through August. Larval and early juvenile Spanish mackerel grow about 1.9 mm d^{-1} for their first 23 days. Growth then increases to nearly 5 mm d^{-1} until about 40 days of age, when growth slows to 2.1 mm d^{-1} (Peters and Schmidt 1997). Ninety-five percent of females along the Atlantic coast are mature by age-1 and 14.1" fork length (FL). All males are mature at age-1 and 13.3" FL (Schmidt *et al.* 1993). Females can get older and grow to larger sizes than males. On the Atlantic coast, the oldest females reach about age-11 and 29.1" FL, and the oldest males reach about age-6 and 18.3" FL (Schmidt *et al.* 1993). In South Florida and the Gulf of Mexico, maximum observed ages were 9 years (28.8" FL) for females and 7 years (26.4" FL) for males (Fable *et al.* 1987).

Table 1. Von Bertalanffy growth parameters and length-weight relations for Spanish mackerel

Inches FL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Males, south Florida and eastern Gulf	0.27	30.6	-0.73	Fable <i>et al.</i> (1987)
Females, south Florida and eastern Gulf	0.38	28.8	-0.73	Fable <i>et al.</i> (1987)
Males, southeastern U.S.	0.31	21.2	-2.31	Schmidt <i>et al.</i> (1993)
Females	0.24	28.5	-1.80	Schmidt <i>et al.</i> (1993)

Weight in lbs = $a(\text{inches SL})^b$	a	b	Source
Males	0.000533	2.9822	Powell (1975)
Females	0.000193	3.1373	Powell (1975)

Spanish mackerel are primarily piscivorous, preying heavily on small schooling fishes in the families Clupeidae, Carangidae, and Engraulidae (Saloman and Naughton 1983b). Small Spanish mackerel preyed mainly on anchovies, while larger Spanish mackerel consumed mainly Spanish sardine and round scad in the Carolinas, east-central Florida, and northwest Florida. Other prey include sciaenids, alewife, menhaden, scaled sardine, Atlantic thread herring, striped mullet, needlefish, lookdown, and butterfish (Finucane *et al.* 1990). Dolphins feed on Spanish mackerel, as do many sharks, including bull shark, dusky shark, smooth hammerhead, porbeagle, and tiger shark (Bigelow and Schroeder 1948; Kemp 1949; Lukens 1989).

Landings of Spanish mackerel totaled 7,336,054 pounds in Florida during 2001. The recreational fishery accounted for 59% of the total statewide landings. Fifty-four percent of the statewide landings in 2001 were made on the gulf coast. Spanish mackerel are caught seasonally throughout Florida's coastal waters. During 2001, commercial catches were greatest in east-central Florida from Brevard County south to Palm Beach County and on the gulf coast in Monroe, Collier, Lee, and Pinellas counties (Fig. 1). Recreational landings were high in the east-central region of the Atlantic coast and along the entire gulf coast (Fig. 2).

Since 1986, the Florida Fish and Wildlife Conservation Commission has employed quotas, trip-limits, bag limits, and size limits to manage Spanish mackerel in state waters. The federal Fishery Management Councils began compatible regulations in 1987. The 2001 total landings of Spanish mackerel were 54% higher than the average landings in the previous five years (1996–2000) and were 3% higher than the 1982–2001 historical average landings (Fig. 3). Total landings of Spanish mackerel have fluctuated between 2 and 4 million pounds on the Atlantic coast since 1984 (Fig. 3). Gulf-coast landings ranged from 4 to 6 million pounds during 1987–1994 but recently declined after the elimination of gill nets from nearshore waters. Annual landings on the gulf coast during 1995–2000 were about 2.2 million pounds.

Catch rates for commercial fishers have increased on the Atlantic coast since 1994. The commercial catch rates on the gulf coast increased from 1986 through 1994, declined sharply during 1996 and 1997—reflecting the elimination of gill nets from state waters—and have since increased slightly in recent years (Figs. 4, 5). On both coasts, recreational catch rates, which generally fluctuated without trend during 1982–1994, have demonstrated a trend toward increase since 1995 (Figs. 6, 7).

Under Section 303 of the Magnuson-Stevens Act, regional fishery management councils are charged with assessing the condition of their stocks; Technical Guidelines (Restrepo *et al.* 1998) set forth procedures for identifying biomass-based measures such as Maximum Sustainable Yield (MSY), the Maximum Fishing Mortality Threshold (MFMT), and the Minimum Spawning Stock Threshold (MSST). The councils specified $F_{30\%SPR}$ as a proxy for F_{MSY} for both Atlantic and gulf Spanish mackerel migratory groups. The MFMT is the fishing mortality rate at 30% spawning potential ratio, $F_{30\%SPR}$, and the MSST is $(1.0 - M)$ times the spawning biomass producing Maximum Sustainable Yield (B_{MSY}). These measures replace the spawning potential ratios as management objectives. The National Marine Fisheries Service updated the assessments for the both the Atlantic and the U.S. gulf Spanish mackerel stocks in 2001 (Mackerel Stock Assessment Panel 2001). The spawning stock of both groups was projected to continue to increase since dropping to lows in 1989 (gulf) or 1991 (Atlantic). For the Atlantic Spanish mackerel in 2000–2001, with a natural mortality rate of $M = 0.30$, none of the outcomes from 400 simulation runs estimated the spawning biomass at less than B_{MSY} . Similarly, none of the outcomes estimated the fishing mortality rate in 2000–2001 at greater than F_{MSY} . Thus, the panel concluded that the Atlantic Spanish mackerel was neither overfished nor undergoing overfishing. For the gulf Spanish mackerel migratory group in 2000–2001, with a natural mortality rate of $M = 0.20$, less than one percent of the outcomes from 400 simulation runs estimating the spawning biomass were less than B_{MSY} . One percent of the outcomes estimated the fishing mortality rate in 2000–2001 were greater than F_{MSY} . Gulf Spanish mackerel are not overfished nor are they undergoing overfishing.

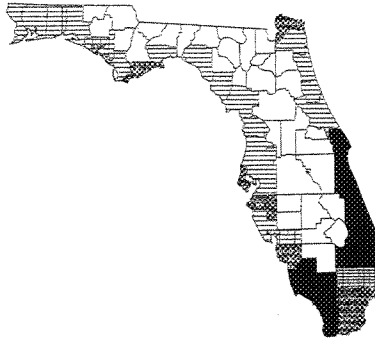


Figure 1. Geographic distribution of commercial Spanish mackerel landings during 2001

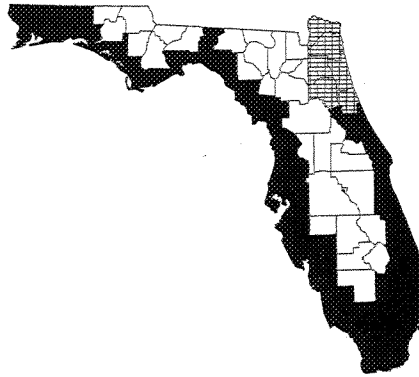


Figure 2. Geographic distribution of recreational Spanish mackerel landings during 2001

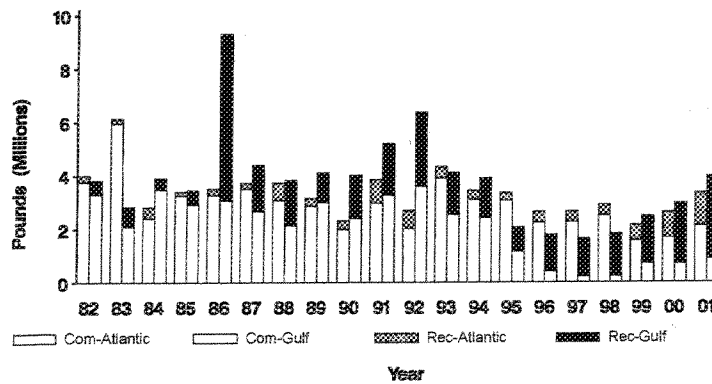


Figure 3. Total annual landings of Spanish mackerel on the Atlantic and gulf coasts of Florida during 1982–2001

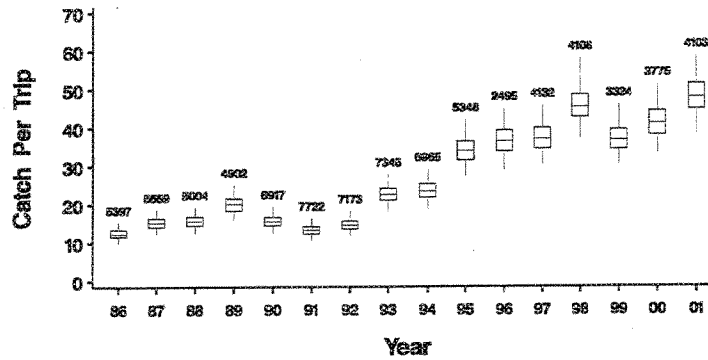


Figure 4. Standardized commercial catch rates (pounds) for Spanish mackerel on the Atlantic coast of Florida, 1986–2001

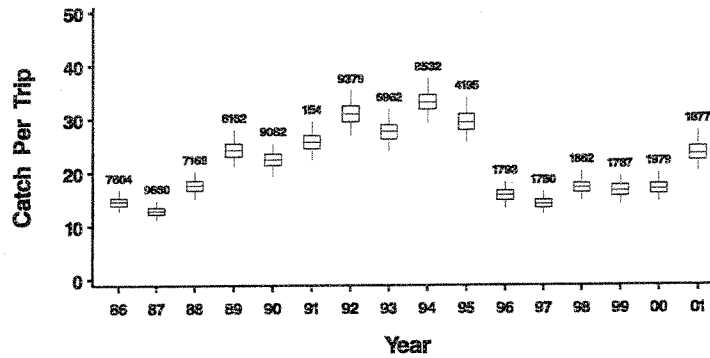


Figure 5. Annual standardized commercial catch rates (pounds) for Spanish mackerel on the gulf coast of Florida, 1986–2001

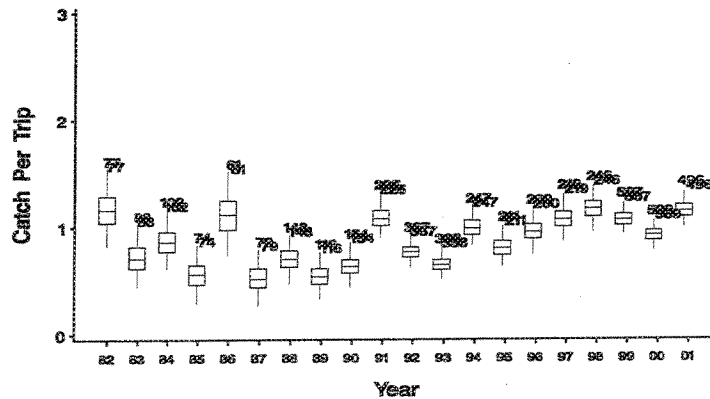


Figure 6. Annual standardized recreational total-catch rates (numbers) for Spanish mackerel on the Atlantic coast of Florida, 1982–2001

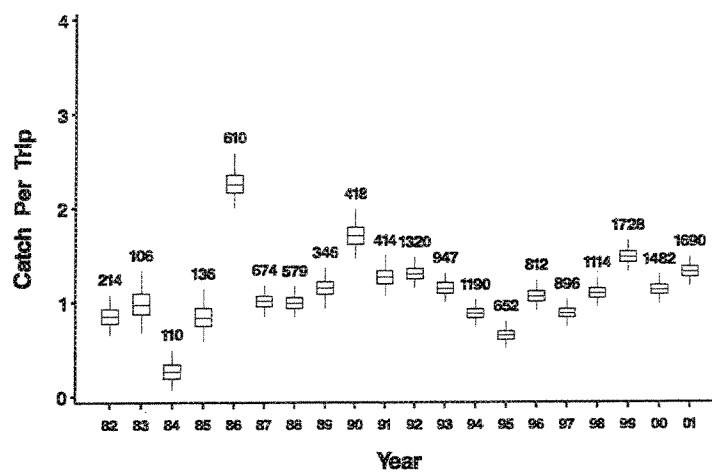
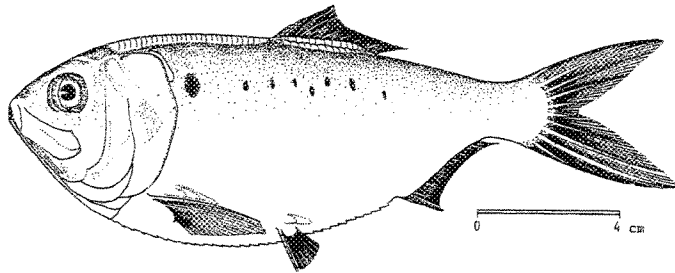


Figure 7. Annual standardized recreational total-catch rates (numbers) for Spanish mackerel on the gulf coast of Florida, 1982–2001

Menhaden, *Brevoortia* spp



The menhaden genus (*Brevoortia*) belongs to the family Clupeidae. Three species occur in the Gulf of Mexico: gulf menhaden (*B. patronus*), finescale menhaden (*B. gunteri*) and yellowfin menhaden (*B. smithi*). Gulf menhaden are characterized by large scales, a series of smaller spots on the body behind the scapular spot, and radiating striations on the upper part of the opercle. Yellowfin and finescale menhaden have smaller scales and do not have the smaller spots and strong opercular striations (Hildebrand 1948). Gulf menhaden range from the Yucatan in Mexico to Tampa Bay, Florida. The finescale menhaden occurs from Mississippi Sound to the Gulf of Campeche in Mexico; yellowfin menhaden range from Chandeleur Sound, Louisiana, southward to the Caloosahatchee River, Florida (presumably around the Florida peninsula), to Cape Lookout, North Carolina (Hildebrand 1948, Christmas and Gunter 1960). The only other Atlantic coast menhaden species is Atlantic menhaden (*B. tyrannus*), which occurs from Nova Scotia to Jupiter Inlet, Florida. Atlantic menhaden, which lack a bright yellow caudal fin, can be distinguished from yellowfin menhaden in several ways; Atlantic menhaden have larger coarser scales in regular rows, pointed (vs rounded) scale pectination, and a row of lateral spots behind the humeral spot (Dahlberg 1970). Among menhaden species, *B. patronus* is the most abundant species on the gulf coast, and *B. tyrannus* is the most abundant species on the Atlantic coast.

Menhaden are estuarine-dependent species. Spawning occurs offshore, and young move into estuarine nursery areas where they spend the early part of their lives. Maturing adults return to offshore waters to spawn (Lewis and Roithmayer 1981). The gulf menhaden form large surface schools, appearing in nearshore gulf waters from about April to November. Tagging information shows that gulf menhaden do not undergo extensive coastwide migration. Spawning peaks during December and January in offshore waters (Lewis and Roithmayer 1981). Eggs hatch at sea, and currents carry larvae into estuaries where larvae develop into juveniles (Christmas and Gunter 1960). Juveniles migrate offshore during winter and move back to coastal waters the following spring as age-1 adults. Initial growth is rapid, and adults reach a size of approximately 4.9 inches fork length (FL) by age 1. Significant growth continues through age 3. Individuals reach approximately 6.7 inches FL at age 2, about 7.9 inches FL at age 4, and about 9.2 inches FL at age 5. Gulf menhaden may reach a maximum age of five to six years (Ahrenholtz 1991). Lewis and Roithmayer (1981) concluded that spawning occurs for the first time at age 1 as the fish approach their second birthday.

Atlantic menhaden spawn primarily from January to March in the South Atlantic Bight. Most females are sexually mature at age 3 (Judy and Lewis 1983). Eggs hatch in 36–48 hours. The larvae are passive drifters and are transported inshore by currents. During the following spring, they enter the fishery at age 1. They may ultimately reach a length of 14 inches FL at

their maximum age of 8 or 9 years (Schaaf 1979). Atlantic menhaden make extensive coastwise migrations. In mid-winter, nearly all menhaden are concentrated in offshore waters south of Cape Hatteras, North Carolina. They begin a slow inshore and northward movement in late February and March. By about mid-June they are stratified by age and size along the coast from northern Florida to the Gulf of Maine. In late summer, a southward movement begins (Schaaf 1979).

Table 1. Von Bertalanffy growth parameters and length-weight relations for the gulf and Atlantic menhaden species

Inches FL = $L_{\infty}(1 - e^{-K(\text{age} - t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Sexes combined, gulf menhaden	0.56	8.9	-0.43	Vaughan et al. (2000)
Sexes combined, Atlantic menhaden	0.30	18.9		Vaughan and Smith (1988)

Weight in lbs = $a(\text{inches FL})^b$	a	B	Source
Sexes combined, gulf menhaden	0.00000149	3.2	Vaughan et al. (2000)
Sexes combined, Atlantic menhaden	0.00000322	3.067	Epperly (1981)

Menhaden are selective feeders throughout most of the larval stage. Juveniles and adults are omnivorous filter feeders (Ahrenholtz 1991). Deegan (1985) demonstrated that gulf menhaden have two mechanisms (microbial cellulase activity and a gizzard-like stomach) that allow digestion of detritus. Because of their high abundance and schooling behavior, menhaden are prey for a large number of piscivorous fish and birds (Overstreet and Heard 1982).

In Florida, menhaden are primarily used for bait in the commercial and recreational fisheries. The annual statewide landings of menhaden during 2001 were 569,500 pounds. The recreational fishery made 55% of the statewide landings. Commercial landings were greater on the Atlantic coast where about 68% of the statewide landings were made in 2001. Commercial landings in 2001 were greatest in the west coast Florida counties of Franklin, Dixie, and Collier (Fig. 1). Recreational landings were equally distributed along the east and west coast of Florida (Fig. 2).

This fishery, formerly centered along the Panhandle coast, has been severely limited by Florida's constitutional amendment restricting the use of purse seine nets in Florida waters. For instance, the average annual Florida gulf coast commercial landings were only 145,042 pounds during 1997–2001 compared to the annual average of 12.3 million pounds during 1986–1994 (Fig. 3). The annual Florida gulf coast recreational landings of menhaden have averaged about 760,781 fish (approximately 152,000 pounds) during 1997–2001. The Atlantic coast commercial fishery landed most of its fish (about 266,710 pounds) in the waters off the central northeast coast of Florida in 2001 (Fig. 1). The Atlantic coast commercial landings have declined from an annual average of 2.3 million pounds during 1990–1994 to about 369,867 pounds during 1997–2001 due to net limitations (Fig. 1). The recreational fishery on the east coast landed about 952,552 million fish (or approximately 170,000 pounds) of menhaden in 2001.

Catch rates for the commercial fisheries on the gulf and Atlantic coasts decreased following the 1995 net limitations (Fig. 4, 5).

The indices of abundance for juvenile menhaden have been highly variable on the Atlantic coast and fairly stable on the gulf coast (Figs. 6, 7). No formal stock assessment for Florida menhaden is available at this time; however, the gulfwide stock assessment of the gulf menhaden (Vaughan *et al.* 2000) and full Atlantic stock assessment of the Atlantic menhaden (Vaughan 1998) show that both stocks appear to be reasonably stable.

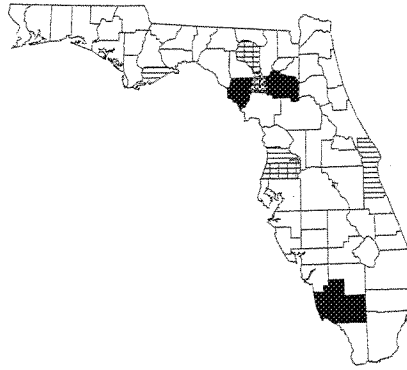


Figure 1. Geographic distribution of commercial landings of menhaden during 2001

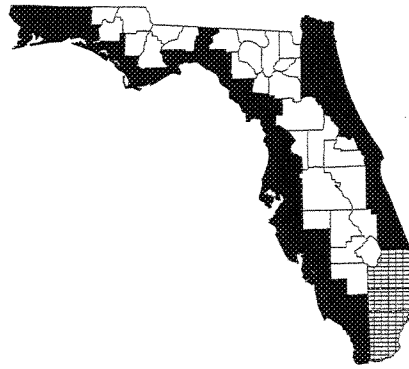


Figure 2. Geographic distribution of recreational landings of menhaden during 2001

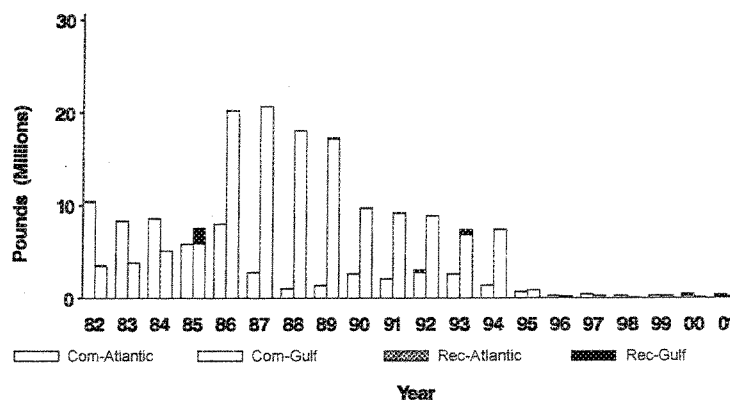


Figure 3. Total annual landings of menhaden on the Atlantic and gulf coasts of Florida, 1982–2001

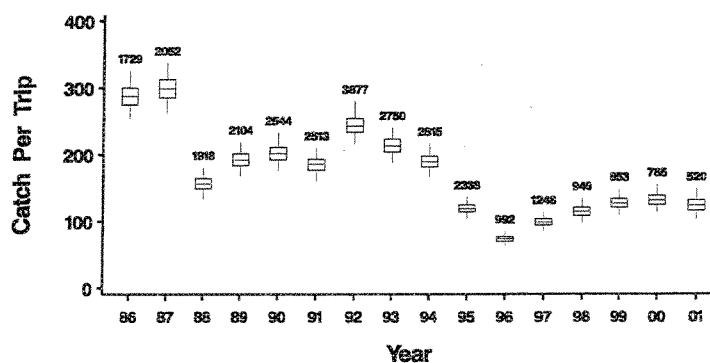


Figure 4. Annual standardized commercial catch rates (pounds) for menhaden on the Atlantic coast of Florida, 1986–2001

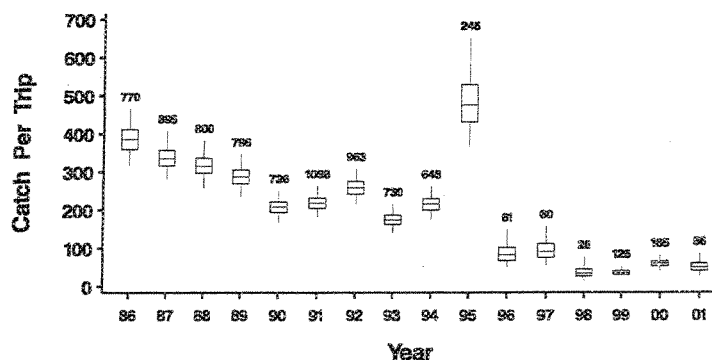


Figure 5. Annual standardized commercial catch rates (pounds) for menhaden on the gulf coast of Florida, 1986–2001

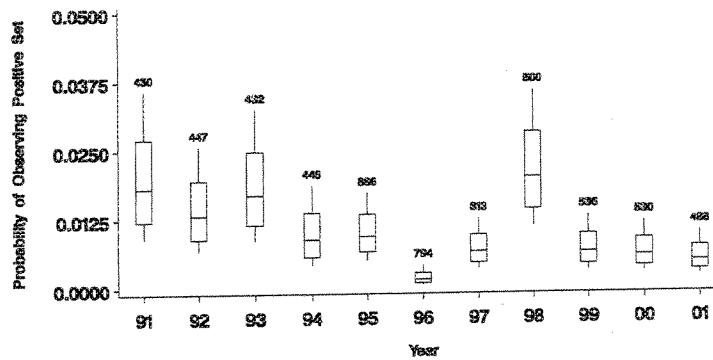


Figure 6. The percentage of Fishery-Independent Monitoring sets that captured young-of-the-year menhaden on the gulf coast, 1991–2001

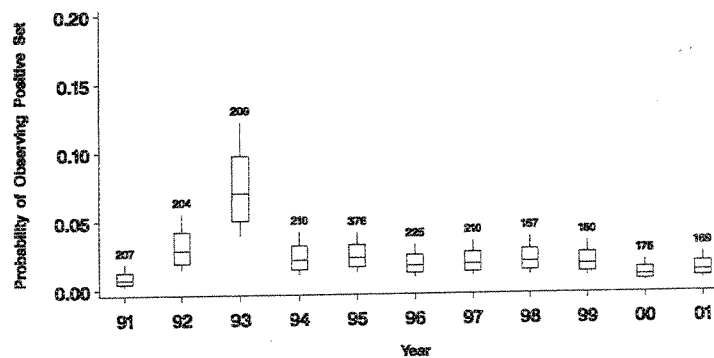
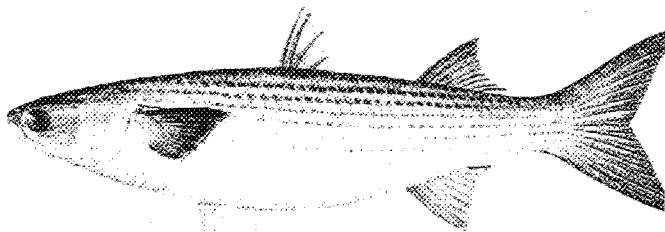


Figure 7. The percentage of Fishery-Independent Monitoring sets that captured young-of-the-year menhaden on the Atlantic coast, 1991–2001

Striped mullet, *Mugil cephalus*



Striped mullet are distributed worldwide in most coastal waters and estuaries of tropical and subtropical seas. They exhibit pronounced population genetic structuring on a global scale, e.g., Mediterranean vs. Galapagos Islands (Crosetti *et al.* 1994), but in Florida, striped mullet are considered one genetic stock (Campton and Mahmoudi 1991). Tagging data show that some striped mullet move between Florida's Atlantic and gulf coasts (Funicelli *et al.* 1989). They have a loosely defined catadromous life cycle, i.e., they reside in fresh waters but spawn in the sea. Juveniles actively recruit to estuaries in Florida and ascend toward freshwater rivers. Striped mullet grow to about 6.1–7.3 inches fork length (FL) in one year and can reach 9–13 years of age. Typically they get no larger than about 20 inches total length (TL) (Leard *et al.* 1995). Females mature at 2–3 years old when about 11.5 inches FL (Leard *et al.* 1995). Spawning occurs in depths of up to 5,400 feet over the outer continental shelf and slope during November through early January.

Table 1. Von Bertalanffy growth parameters and length-weight relations for striped mullet

Inches TL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches TL)	t_0 (years)	Source
Male, Florida central west coast	0.664	14.3	0.003	Mahmoudi (1991)
Female, Florida central west coast	0.385	17.8	-0.127	Mahmoudi (1991)
Male, Apalachicola Bay, Florida	1.071	12.9	-0.168	Mahmoudi (1991)
Female, Apalachicola Bay, Florida	0.848	14.2	-0.110	Mahmoudi (1991)
Male, Pensacola Bay, Florida	0.650	14.2	-0.257	Mahmoudi (1991)
Female, Pensacola Bay, Florida	0.423	16.6	-0.131	Mahmoudi (1991)
Sex combined, Florida Atlantic coast	0.35	18.4	-0.114	Mahmoudi (unpubl. data)
Male, Veracruz, Mexico	0.105	23.7	-2.98	Ibanez Aguirre et al. (2000)
Female, Veracruz, Mexico	0.107	24.5	-2.67	Ibanez Aguirre et al. (2000)

Weight in lbs = $a(\text{inches TL})^b$	a	b	Source
Male, Florida central west coast	0.000313	3.196	Mahmoudi (1991)
Female, Florida central west coast	0.000363	3.149	Mahmoudi (1991)
Male, Apalachicola Bay, Florida	0.000630	2.928	Mahmoudi (1991)
Female, Apalachicola Bay, Florida	0.000282	3.239	Mahmoudi (1991)
Male, Pensacola Bay, Florida	0.000691	2.881	Mahmoudi (1991)
Female, Pensacola Bay, Florida	0.000537	2.979	Mahmoudi (1991)
Sex combined, Florida Atlantic coast	0.000298	3.984	Mahmoudi (unpubl. data)
Sex combined, Veracruz, Mexico	0.000622	2.80	Ibanez Aguirre et al. (1999)

Diet and feeding behavior of juvenile and adult striped mullet may vary by location, but they primarily feed on epiphytic and benthic microalgae, macrophyte detritus, or inorganic sediment particles. Sediment particles function as a grinding paste in the gizzard-like pyloric portion of the stomach (Odum 1970). Larval and post-larval mullet feed on zooplankton (Nash *et al.* 1974). The major predators of juvenile and adult mullet are fishes and birds (Thomson 1963). Among fishes, common snook, spotted seatrout, red drum, hardhead catfish, southern flounder, bull shark, and alligator gar are known to prey on mullet (Gunter 1945, Breuer 1957, Simmons 1957, Darnell 1958). Wading birds also prey on mullet (Powell, unpublished data cited by Sogard *et al.* 1989).

Striped mullet harvest, under increasing regulation since 1989, was severely restricted by Florida's 1995 constitutional amendment eliminating the use of entangling nets in Florida waters. This caused a rapid decline in landings, especially on the gulf coast, in 1995. The statewide total landings of striped mullet have increased since 1995, reaching an annual average of about 10.5 million pounds during 1999–2000, a level less than half of the peak landings of 28 million pounds made in 1989. In 2001, total landings of striped mullet were 12,145,355 pounds. The commercial fishery made 84% of landings. Landings were greater on the gulf coast, where about 88% of the statewide landings were made in 2001. Nearly every coastal county and one interior county reported commercial landings during 2001 (Fig. 1). Recreational landings were high along most of the Atlantic coast and in all regions on the gulf coast (Fig. 2).

The 2001 total landings of striped mullet, 22% higher than the average landings in the previous five years (1996–2000), were 39% lower than the 1982–2001 historical average landings (Fig. 3). Total landings of striped mullet on the Atlantic coast have fluctuated without trend since 1982, ranging from about 1.5 to 5.0 million pounds (Fig. 3). Total annual landings on the gulf coast varied without trend during 1982–1991, ranging from about 22 to 26 million pounds. Between 1991 and 1995, however, total annual landings of striped mullet on the gulf coast dropped sharply, partially in response to increasingly restrictive regulations. Since reaching 5.1 million pounds in 1996, mullet annual landings on the gulf coast increased to about 8.8 million pounds in 2000 and 10.7 million pounds in 2001.

Trends in commercial catch rates for mullet are strongly influenced by changes in quotas, gear restrictions, time closures occurring during 1989–1993, and by the July 1995 elimination of entangling nets. Commercial catch rates on both coasts varied without trend between 1986 and 1993, showed a gradual decline through 1994, and a marked drop in 1995 (Figs. 4, 5). Since then, catch rates have increased. Recreational catch-rate estimates are imprecise for striped mullet; available estimates show a recent declining trend on the Atlantic coast and a low but stable level in recent years on the gulf coast (Figs. 6, 7). Indices of abundance for juvenile striped mullet appear to show strong recruitment to inshore waters in 1996 on the Atlantic coast and in 1998 and 2001 on the gulf coast (Figs. 8, 9).

The assessment of the striped mullet population in 2000 found that transitional spawning potential ratios (SPR) had increased to 35%, thus the stock was not considered overfished for the first time since a threshold of 35% transitional SPR had been established (Mahmoudi 2000). Fishing mortality rates were also sufficiently low in 2000 to indicate that overfishing was not occurring at that time.

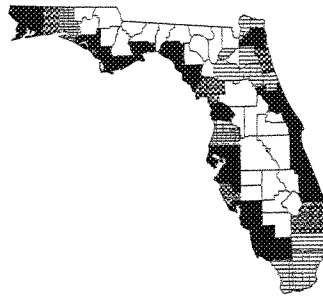


Figure 1. Geographic distribution of commercial landings of striped mullet during 2001

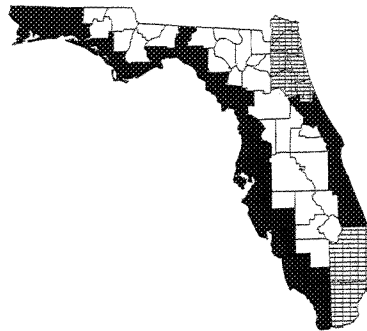


Figure 2. Geographic distribution of recreational landings of striped mullet in 2001

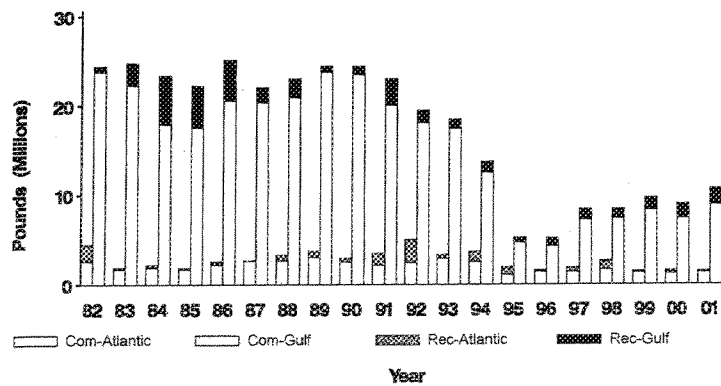


Figure 3. Total annual landings of striped mullet on the Atlantic and gulf coasts of Florida, 1982–2001

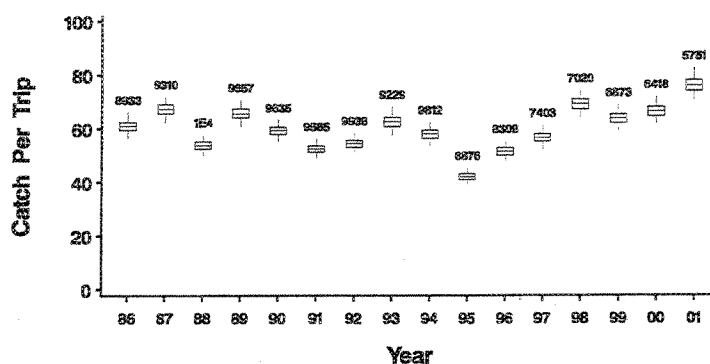


Figure 4. Annual standardized commercial catch rates (pounds) for striped mullet on the Atlantic coast of Florida, 1986–2001

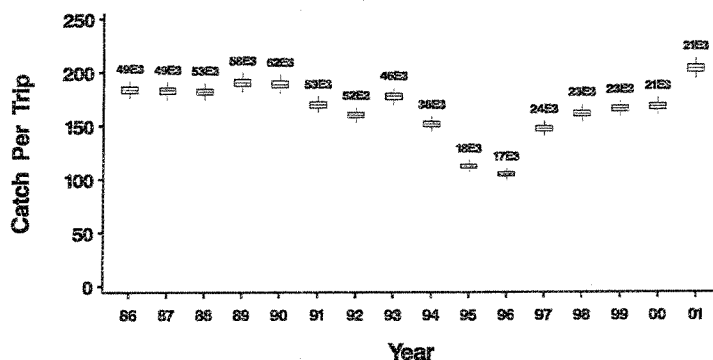


Figure 5. Annual standardized commercial catch rates (pounds) for striped mullet on the gulf coast of Florida, 1986–2001

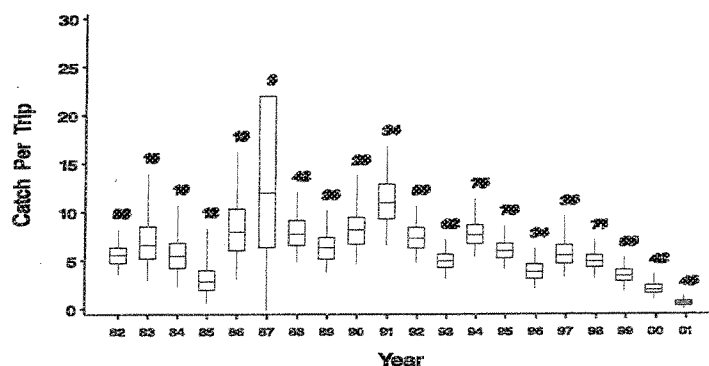


Figure 6. Annual standardized recreational total-catch rates (numbers) for striped mullet on the Atlantic coast of Florida, 1982–2001. The 97.5th percentile for 1987 was truncated to maintain the scale. Its actual value is greater than 189 per trip.

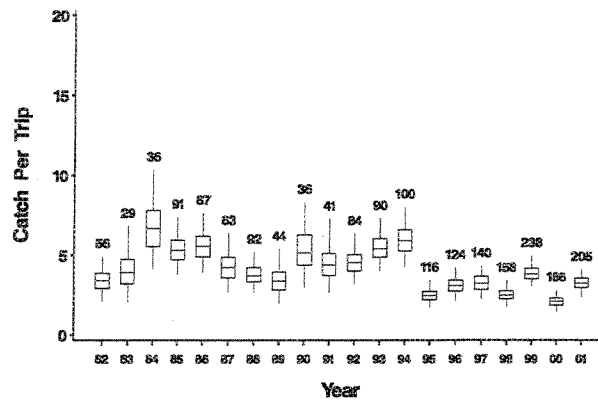


Figure 7. Annual standardized recreational total-catch rates (numbers) for striped mullet on the gulf coast of Florida, 1982–2001

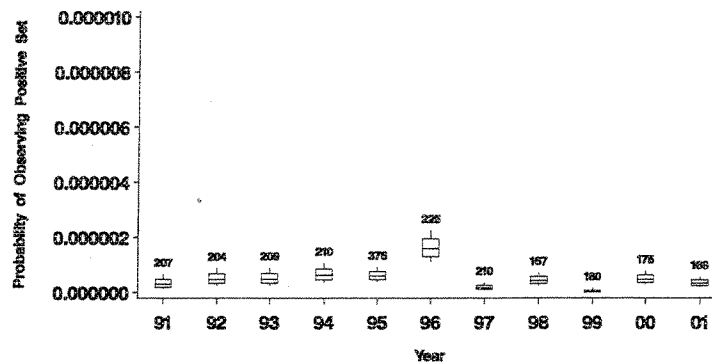


Figure 8. Percentage of Fishery-Independent Monitoring sets that captured young-of-the-year striped mullet on the Atlantic coast, 1991–2001

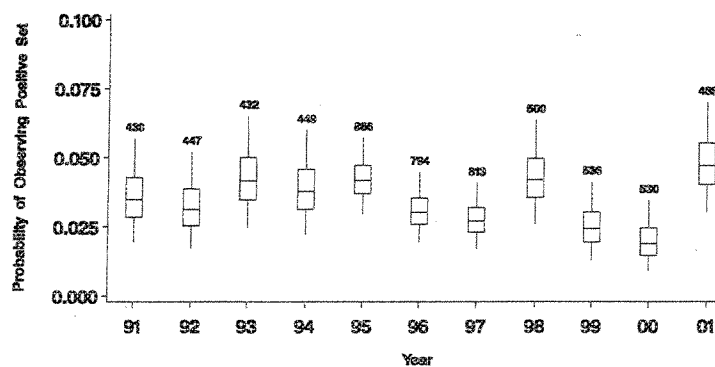
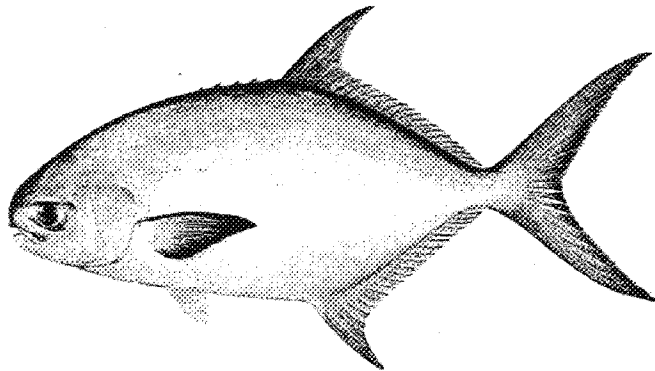


Figure 9. Percentage of Fishery-Independent Monitoring sets that captured young-of-the-year striped mullet on the gulf coast, 1991–2001

Florida pompano, *Trachinotus carolinus*



Florida pompano occur in western Atlantic coastal waters from Cape Cod, Massachusetts to southeastern Brazil. In U.S. waters, they are uncommon north of Chesapeake Bay. Pompano are found year-round in Florida but move north and south in response to the 15°C isotherm in nearshore waters (Berry and Iverson 1967). Florida pompano mature before reaching a total length (TL) of 14 inches (Finucane 1969). Mature fish have been found as small as about 10 inches fork length (FL) and as young as age 1 (FWC-FMRI, unpublished data). The oldest fish examined in an FWC-FMRI study was estimated to be 7 years old. Spawning is thought to occur in offshore waters, e.g., near the Gulf Stream at 660' depths (Fields 1962). Peak spawning activity occurs during the spring and fall (Finucane 1969).

Table 1. Von Bertalanffy growth parameters and length-weight relations for pompano

Inches FL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Male, Atlantic coast, Florida	0.13	18.3	-5.6	Murphy <i>et al.</i> (1996)
Female, Atlantic coast, Florida	0.27	18.1	-2.4	Murphy <i>et al.</i> (1996)
Male, gulf coast, Florida	0.37	14.3	-2.6	Murphy <i>et al.</i> (1996)
Female, gulf coast, Florida	0.55	15.3	-1.2	Murphy <i>et al.</i> (1996)

Weight in lbs = $a(\text{inches FL})^b$	a	b	Source
Male, Atlantic coast, Florida	0.001292	2.821	Murphy <i>et al.</i> (1996)
Female, Atlantic coast, Florida	0.002943	2.501	Murphy <i>et al.</i> (1996)
Male, gulf coast, Florida	0.00150	2.773	Murphy <i>et al.</i> (1996)
Female, gulf coast, Florida	0.00110	2.901	Murphy <i>et al.</i> (1996)

Pompano are generalized benthic feeders that use large well-developed pharyngeal plates to crush hard-shelled prey (Bellinger and Avault 1971). In Tampa Bay, small juvenile pompano (0.6–1.8 inches standard length) shift from eating amphipods, dipteran larvae, and coquina clams to eating larger crustaceans, mollusks, and occasionally fishes. Diets of adult pompano from the Indian River lagoon consist primarily of infaunal bivalves (Armitage and Alevizon 1980). In Tampa Bay, adults chiefly eat mussels and penaeid shrimp (Finucane 1969).

During 2001, the estimated landings of Florida pompano in Florida were 1,004,106

pounds. In 2001, recreational anglers accounted for about 69% (up from 58% in 2000) of the total statewide landings. About 68% of the statewide landings were made on the gulf coast in 2001. Commercial landings were made mostly in Brevard and St. Lucie counties on the Atlantic coast and in Pinellas, Collier, and Lee counties on the gulf coast (Fig. 1). Landings of pompano made by the recreational fishery occurred mostly in the east-central region on the Atlantic coast and the southwest region on the gulf coast (Fig. 2).

The 2001 total landings were similar to the average landings in the previous five years (1996–2000) and were 10% higher than the 1982–2001 historical average landings (Fig. 3). Total annual landings fluctuated without trend on the Atlantic coast between 1982 and 1997; although, both 1998 and 2000 landings were near historic high levels (Fig. 3). Gulf coast annual landings also fluctuated without trend until 1992, when they began a slow decline that lasted through 1996. Total annual landings increased sharply on the gulf coast in 1997 and 1998, declined slightly in 1999 and 2000, and increased again in 2001.

Commercial catch per trip for Florida pompano fluctuated without trend on the Atlantic coast and has increased in recent years on the gulf coast (Figs. 4, 5). Recreational catch rates on the Atlantic peaked in 1997 and have since declined (Fig. 6). On the gulf coast, anglers' catch rates have been low and stable since at least 1992 (Fig. 7).

The 2002 stock assessment (Muller et. al., 2002) indicated that pompano fishing mortality rates were higher than the fishing mortality rate that would produce maximum sustainable yield. In 2000, the F/F_{MSY} ratio was 1.64 on the Atlantic coast and 1.20 on the gulf coast. The estimated biomass on the Atlantic coast was half (49%) of that associated with maximum sustainable yield, and fishing mortality rates were increasing. After 1995, the biomass ratio on the gulf coast increased to the 1997 level of 1.09. However, fishing mortality rates have increased to their previous levels, and the biomass ratio dropped to 0.8 in 2000.

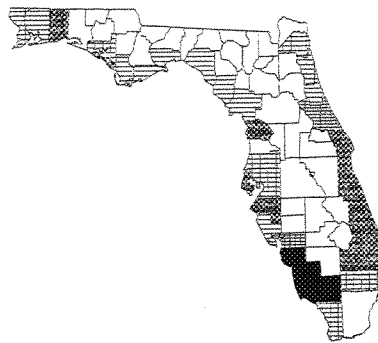


Figure 1. Geographic distribution of commercial landings of Florida pompano during 2001

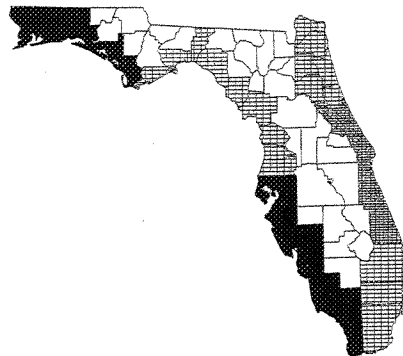


Figure 2. Geographic distribution of recreational landings of Florida pompano during 2001

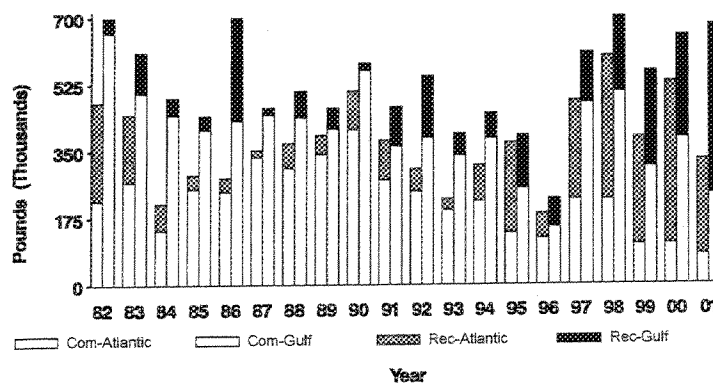


Figure 3. Total annual landings of Florida pompano on the Atlantic and gulf coasts of Florida, 1982–2001

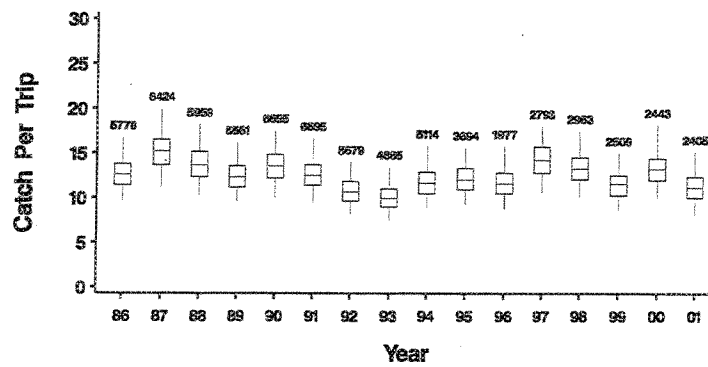


Figure 4. Annual standardized commercial catch rates (pounds) for Florida pompano on the Atlantic coast of Florida, 1986–2001

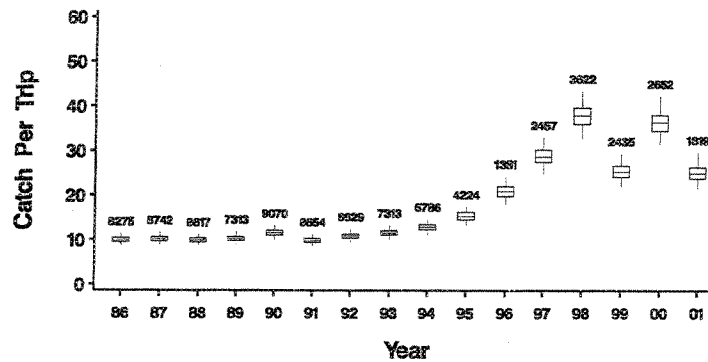


Figure 5. Annual standardized commercial catch rates (pounds) for Florida pompano on the gulf coast of Florida, 1986–2001

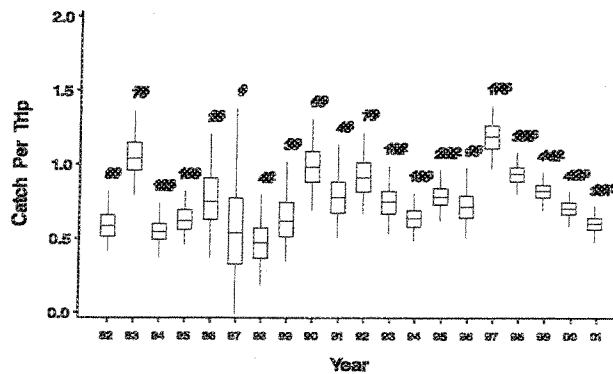


Figure 6. Annual standardized recreational total-catch rates (numbers) for Florida pompano on the Atlantic coast of Florida, 1982–2001

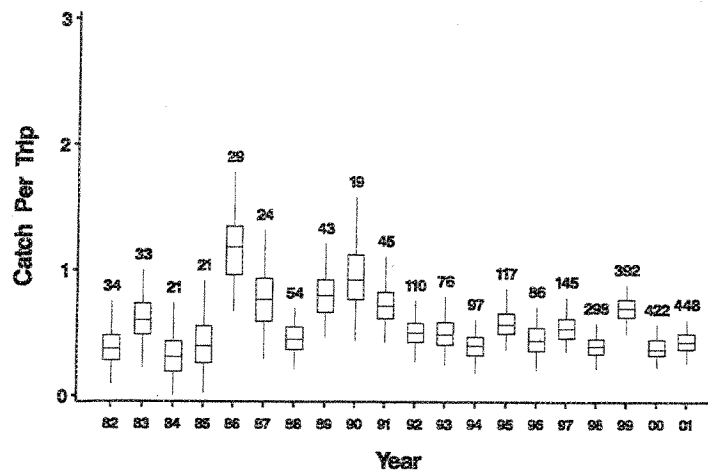
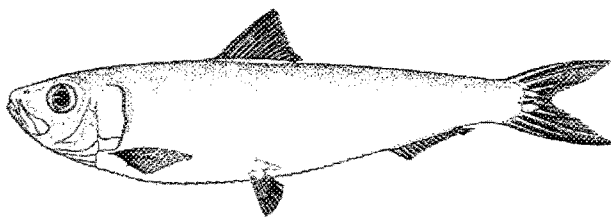


Figure 7. Annual standardized recreational total-catch rates (numbers) for Florida pompano on the gulf coast of Florida, 1982–2001

Spanish sardine, *Sardinella aurita*



Spanish sardines occur throughout Florida state waters, from waters on the continental shelf into the mouths of large estuaries. The species ranges from Cape Cod, Massachusetts to Rio de Janeiro, Brazil (Grall 1984). Eastern Gulf of Mexico individuals are composed of one genetic stock (Tringali and Wilson 1993), but the stock structure along the eastern U.S. seaboard and in the western Gulf of Mexico is unknown. In general, Spanish sardines show low genetic diversity that appears to be the result of occasional large declines in abundance (population bottlenecks) and a high reproductive success of a small number of females (Chikhi *et al.* 1998). Morphological variation found in juvenile Spanish sardine in Florida appeared to reflect short-term environmental differences (Kinsey *et al.* 1994). The distribution of Spanish sardine extends from the beach to depths of about 100'–130', but the highest densities are usually found in the nearshore waters (15'–65'). The species has a typical pelagic behavior with diel vertical migration; it remains in tight schools close to the bottom during the daytime and becomes more scattered throughout water column at night.

Spanish sardine spawn in spring and summer, mainly in mid-shelf waters along the west coast (Houde *et al.* 1979). After spawning, most adults undertake a feeding migration toward nearshore coastal waters. Spanish sardine off Florida have short life spans (4 years) and can reach a fork length of 7.5 inches. Growth is sexually differentiated; females present higher growth rates and larger maximum lengths than males (Sutter *et al.* 1992). Maximum ages of 3–4 years and fork length of 7.5–7.9 inches for females and 6.7–7.5 inches for males have been commonly observed. Length of first maturity is 4.3 inches (one-year-old fish). Outside of Florida waters, Spanish sardines have been observed to reach 7–8 years age (Ben-Tuvia 1960).

Table 1. Von Bertalanffy growth parameters and length-weight relations for Spanish sardine

Inches FL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Male, west coast Florida	0.65	7.75	-0.6604	Grall (1984)
Female, west coast Florida	0.47	8.66	-0.3810	Grall (1984)
Male, west coast Florida	0.783	6.97		Sutter <i>et al.</i> (1992)
Female, west coast Florida	0.733	7.17		Sutter <i>et al.</i> (1992)

Weight in lbs = $a(\text{inches FL})^b$	a	b	Source
Male, west coast Florida	0.0000556	2.85	Grall (1984)
Female, west coast Florida	0.000275	3.28	Grall (1984)
Male, west coast Florida	0.000424	3.054	Sutter <i>et al.</i> (1992)
Female, west coast Florida	0.000419	3.05	Sutter <i>et al.</i> (1992)

Juvenile Spanish sardines feed mainly on copepods and euphausiids. With growth, decapods and fish (mainly myctophid) become more important in the Spanish sardine diet (Hildebrand 1964, and Low 1973). Key predators of Spanish sardine include king and Spanish mackerels, little tunny, gag, bluefish, crevalle jack, yellowfin and bluefin tuna, and dolphin (Johnson and Vaught 1986).

Females begin to mature at the end of their second year at a minimum fork length of 5.3 inches; all are mature by age 3 and 7.7 inches long. In the Gulf of Mexico, spawning occurs year-round on the continental shelf in depths ranging from 33–164 feet (Houde *et al.* 1979). Conflicting findings suggest that spawning occurs either year-round with less spawning during May–September (Houde *et al.* 1979) or with peak spawning during April–September (Sutter *et al.* 1992).

The Spanish sardine fishery in Florida is almost exclusively a commercial purse-seine fishery. Total 2001 landings of Spanish sardine in Florida were 1,417,820 pounds. Ninety-eight percent of the statewide landings in 2001 were made on the gulf coast. Landings on the gulf coast were highest in the Panhandle region west of Cape San Blas (Fig. 1). Atlantic commercial landings of Spanish sardine were significant in Palm Beach and Dade counties. Recreational landings estimates were less than 1,000 fish in any of the subregions considered.

The Atlantic fishery appeared to be mainly an incidental catch before 1990 but has persisted since then with relatively low (< 0.35 million pounds) total annual landings (Fig. 2). The fishery on the gulf coast was centered in the Tampa Bay area until the bay was closed to Spanish sardine fishing in 1989. In state waters adjacent to Manatee, Hillsborough, and Pinellas counties, landings were limited by a 4.1-million-pound annual quota between April 1989 and January 1991, after which a 500-pound trip-limit was enacted. Before these regulations, the annual statewide landings of Spanish sardines had already declined from 6.4 million pounds in 1987 to 3.5 million pounds in 1988. Between 1989 and 1994 the state landings were stable at 1.7–2.4 million pounds. In 1995, landings dropped significantly because of the constitutional amendment prohibiting the use of purse-net gear within 3 miles of Florida's gulf coast and within 1 mile of the Atlantic coast. Since then landings have rebounded somewhat, as the commercial fishery adjusted to fishing in offshore waters. The 2001 total landings of Spanish sardine were 16% higher than the average landings in the previous five years (1996–2000) and were 44% lower than the 1982–2001 historical average landings (Fig.2). Commercial purse-seine catch rates have generally increased on the gulf coasts since 1995 (Fig. 3).

The annual biomass estimates, based on trawl mean-swept-area catches, were estimated at about 28 million pounds in 1994 and dropped to about 4 million pounds in 1999 (Mahmoudi *et al.* 2002). Estimated potential yield off west-central Florida in 1999 ranged between 1.5 and 2.2 million pounds, more than two to three times the actual landings. Despite significant reductions in the commercial landings since 1995 on the west coast of Florida, the analysis of fishery-independent trawl-acoustic surveys (1994–2002) indicated that the abundance of important baitfish species (i.e., Spanish sardine, round scad, and Atlantic thread herring) has not increased in recent years (Mahmoudi *et al.*, 2002). Mean trawl catch rates for Spanish sardine and round scad fluctuated, and trends declined in recent years. The Atlantic thread herring catch rates varied without a trend. Catch rates for Spanish sardine and round scad were lowest in 1997, 2001, and 2002; catch rates were lowest in 2001 for Atlantic thread herring. These findings suggest that factors other than fishing may have caused changes in population abundance of

baitfish species in the survey area. A multivariate ANOVA model, relating acoustic baitfish density and environmental variables, indicated that the baitfish density significantly increased in waters with lower salinities and lower temperatures. These relationships may explain reasons for low baitfish trawl catch rates in 1997, 2001, and 2002 when the salinity was near its observed maximum (Mahmoudi *et al.* 2002).

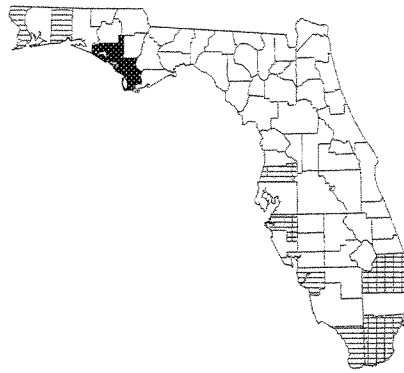


Figure 1. Geographic distribution of commercial landings of Spanish sardine during 2001

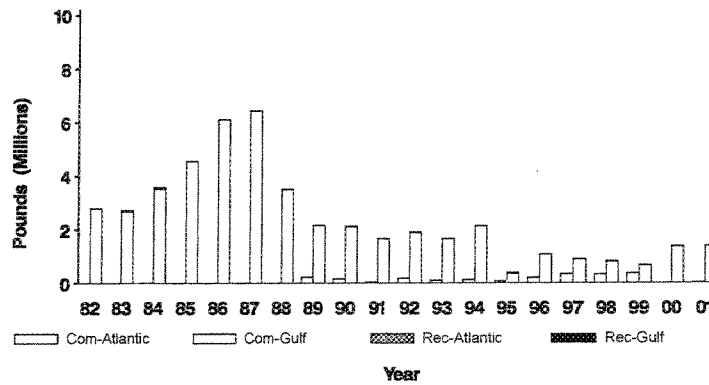


Figure 2. Total annual landings of Spanish sardine on the Atlantic and gulf coasts of Florida, 1982–2001

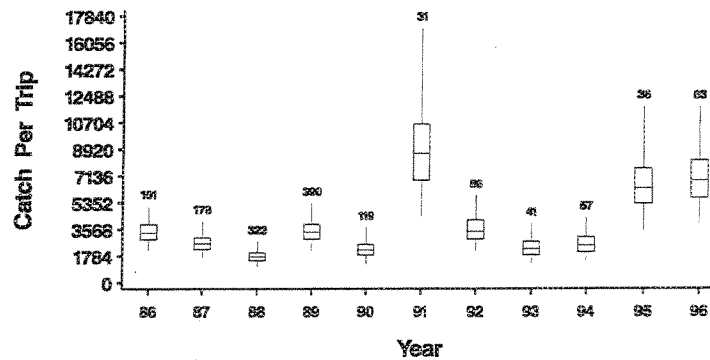
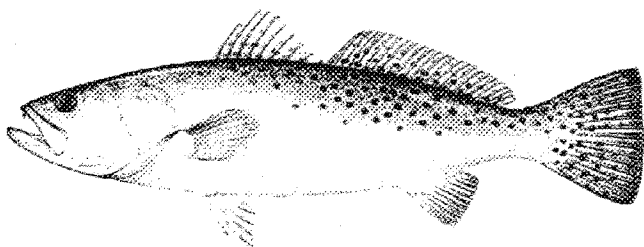


Figure 3. Annual standardized commercial purse-seine catch rates (pounds) for Spanish sardine on the gulf coast of Florida, 1991–2001

Spotted seatrout, *Cynoscion nebulosus*



Spotted seatrout range throughout Florida's bays and coastal waters. Studies indicate that spotted seatrout from various areas of Florida are more genetically isolated from one another as their geographic separation increases (Ramsey and Wakeman 1987, Gold *et al.* 1999). Further, Seyoum and Bert (unpubl. data, FWC-FMRI) found nuclear DNA sequence evidence for three distinct groups of spotted seatrout in Florida: an Atlantic coast group south through Biscayne Bay, a gulf coast group from Biscayne Bay north to Apalachee Bay, and another gulf coast group from Apalachicola westward. Each area may have specific, localized groups of fish that do not intermix regularly with other groups, thus they are affected only by local fishing pressure. Gold and Richardson (1998b) suggested that, based on their genetic analyses of spotted seatrout populations in the Gulf of Mexico, it appeared that female fidelity to their natal estuaries played an important role in maintaining subpopulations. Growth is sex- and area-specific. Males grow more slowly than females, and spotted seatrout in the Indian River Lagoon, and Apalachicola Bay grow more quickly than do those in southwest Florida (Murphy and Taylor 1994). Maximum ages reached in Florida are 9 years for males and 8 years for females. Spotted seatrout first spawn between 0 and 2 years old and 11.8–15.7 inches total length (TL). Spawning occurs within estuaries and in nearshore waters during spring, summer, and fall.

Table 1. Gompertz growth parameters and length-weight relations for the spotted seatrout

Inches TL = $L_{\infty} \exp(e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches TL)	t_0 (years)	Source
Female, Charlotte Harbor, Florida	0.36	27.4	0.39	Murphy and Taylor (1994)
Female, Indian River, Florida	0.36	33.0	0.74	Murphy and Taylor (1994)
Female, Apalachicola, Florida	0.349	32.1	0.68	Murphy and Taylor (1994)

Weight in lbs = $a (\text{inches TL})^b$	a	b	Source
Male, Indian River, Florida	0.000202	3.1731	Murphy and Taylor (1994)
Male, Apalachicola, Florida	0.000509	2.8099	Murphy and Taylor (1994)
Female, Indian River, Florida	0.000231	3.1169	Murphy and Taylor (1994)
Female, Apalachicola, Florida	0.000465	2.8591	Murphy and Taylor (1994)

The diet of juvenile seatrout (<1.2 inches SL) includes amphipods, mysids, and carideans (Hettler 1989). Larger juveniles and adults feed primarily on shrimp and fish such as bay anchovy, gulf menhaden, shad, mullet, sheepshead minnow, gulf toadfish, pipefish, pinfish, pigfish, silver jenny, Atlantic croaker, and spotted seatrout (Hettler 1989; McMichael and Peters 1989).

Spotted seatrout landings totaled 2,522,760 pounds during 2001. The recreational fishery made most (98 % by weight) of the total statewide landings in 2001. Landings were greater on the gulf coast, where about 79% of the statewide landings were made in 2001. Since 1996, the fishery has moved from what was a mixed-sector fishery, with about 20% of the landings made by commercial fishers, to an almost exclusive (>95% by weight) recreational fishery. The small commercial fishery lands spotted seatrout in almost all coastal counties, especially those adjacent to large estuaries or nearshore grassflats, e.g., Lee County on Charlotte Harbor and Volusia, Indian River, and St. Lucie counties on or near the Indian River Lagoon (Fig. 1). Recreational landings made during 2001 were high in all regions except for the Northeast, Panhandle, and Southeast regions (Fig. 2).

The 2001 total landings of spotted seatrout were 6% lower than the average landings in the previous five years (1996–2000) and were 50% lower than the 1982–2001 historical average landings (Fig. 3). Total Atlantic coast annual landings of spotted seatrout dropped sharply in 1996 in at least partial response to increased fishing restrictions such as smaller bag limits, larger minimum size, and closed seasons (Fig. 3). On the gulf coast, total landings fluctuated but generally declined from 1989 to 1996; however, total landings, reflecting the increases in the recreational landings, have increased since 1996 (Fig. 3).

The commercial fishery was under a quota and trip-limit system from November 1989 until January 1996, and this is partially responsible for maintaining stable commercial catch rates through the mid-1990s (Figs. 4, 5). More recently, elimination of entangling nets and the limits on the commercial season in Florida waters severely affected the commercial fishery.. New regulations imposed on the recreational fishery in 1989 and again in 1996 likely resulted in the increased spotted seatrout abundance reflected by the changes in commercial catch rates since 1995 on the Atlantic coast and since 1993 on the gulf coast (Figs. 4, 5). Total-catch rates for anglers increased during 1990 or 1991 then fluctuated at these new higher levels on the Atlantic coast (Fig. 6). Except for a dip in 2000 and 2001, recreational anglers' catch rates on the gulf coast have been increasing since 1996 (Fig. 7).

Since 1991, the indices of abundance for juvenile spotted seatrout fluctuated without trend on both coasts (Figs. 8, 9).

Region-specific estimates of transitional spawning potential ratios (tSPR) have changed little since 1995 according to the 1999 stock assessments of Florida's spotted seatrout (Murphy *et al.* 1999). In the northeast, however, this ratio increased from 23% in 1995 to 37% in 1998. Only in the northeast region did the static spawning potential ratio meet the commission's 35% objective. It appeared that, given the estimated number of recruits and spawning stock biomass, current spotted seatrout reproduction was adequate to sustain current populations in all regions. Muller (1997) showed that Florida's management of spotted seatrout has been a series of regulations adapted to meet changing management goals and regional user-group needs. Preliminary results from a recent stock assessment (Murphy 2003, in review) showed that the average fishing mortality rate for age2⁺ males and females in 2001 was estimated at 0.28 and 0.37 per year in the northeast region. In the southeast region, the rate was 0.82 and 1.01 per year. The rate was 0.38 and 0.43 per year in the southwest region and 0.28 and 0.44 per year in the northwest region. For both sexes, estimates of average fishing mortality have generally declined in all regions but the southeast since the mid 1990s. Results from the 2003 assessment also indicate that recruitment of age-0 spotted seatrout appears to be declining in the southwest and northeast regions, possibly increasing in the southeast, and fluctuating without trend in the

northwest region.

Only in the northeast management region are 2001 fishing rates low enough to achieve and maintain the commission's 35% tSPR target. In the other regions, static SPRs under 2001 fishing mortality rates range from 16 to 29% (Murphy 2003).

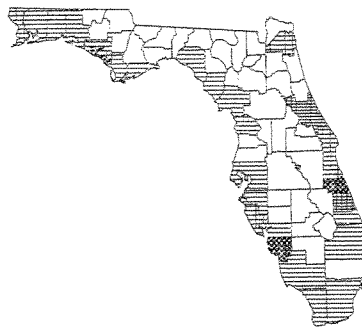


Figure 1. Geographic distribution of commercial landings of spotted seatrout during 2001

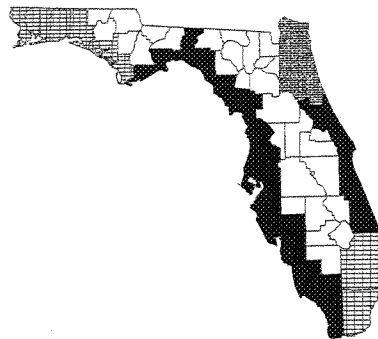


Figure 2. Geographic distribution of recreational landings of spotted seatrout during 2001

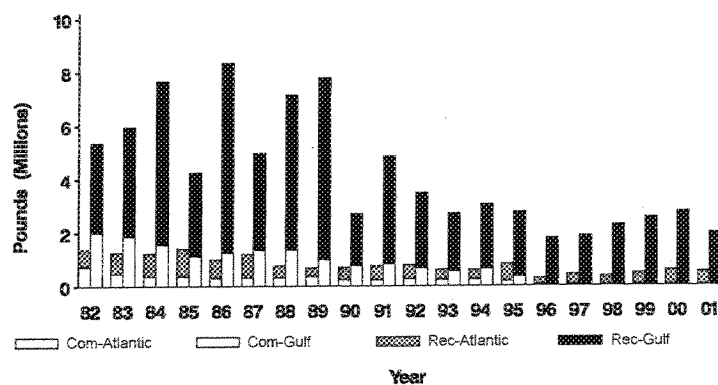


Figure 3. Total annual landings of spotted seatrout on the Atlantic and gulf coasts of Florida, 1982–2001

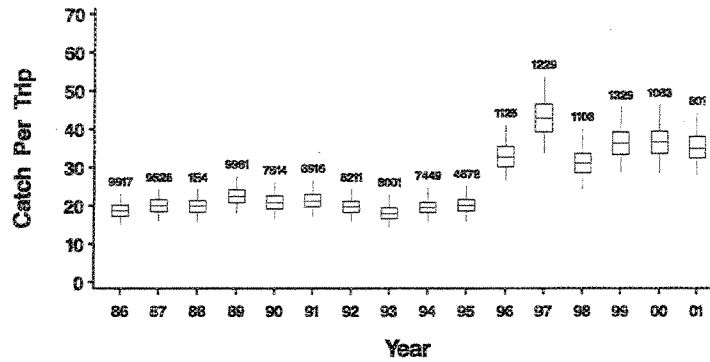


Figure 4. Annual standardized commercial catch rates (pounds) for spotted seatrout on the Atlantic coast of Florida, 1986–2001

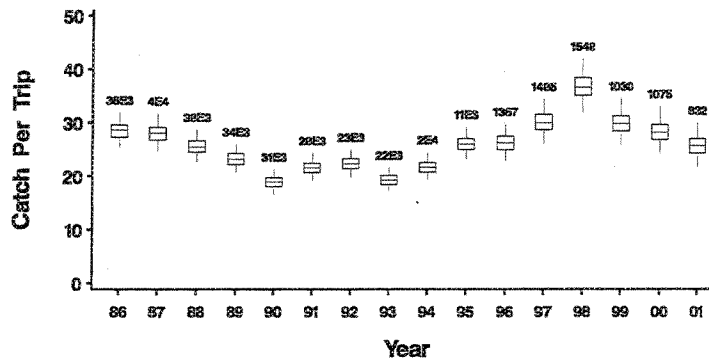


Figure 5. Annual standardized commercial catch rates (pounds) for spotted seatrout on the gulf coast of Florida, 1986–2001

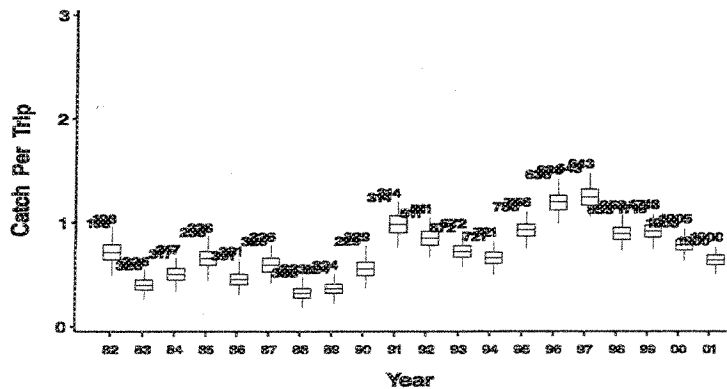


Figure 6. Annual standardized recreational total-catch rates (numbers) for spotted seatrout on the Atlantic coast of Florida, 1982–2001

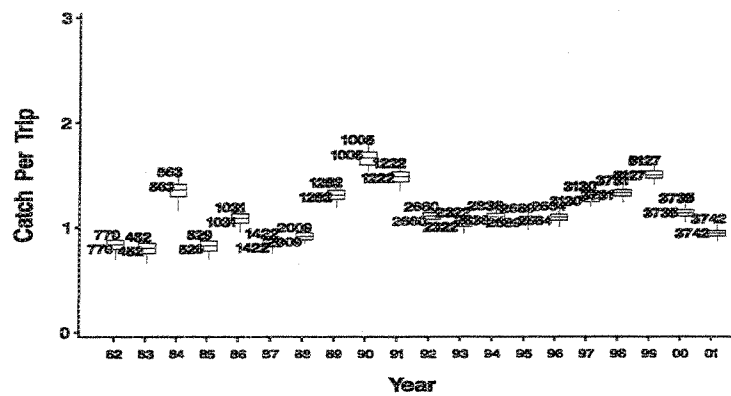


Figure 7. Annual standardized recreational total-catch rates (numbers) for spotted seatrout on the gulf coast of Florida, 1982–2001

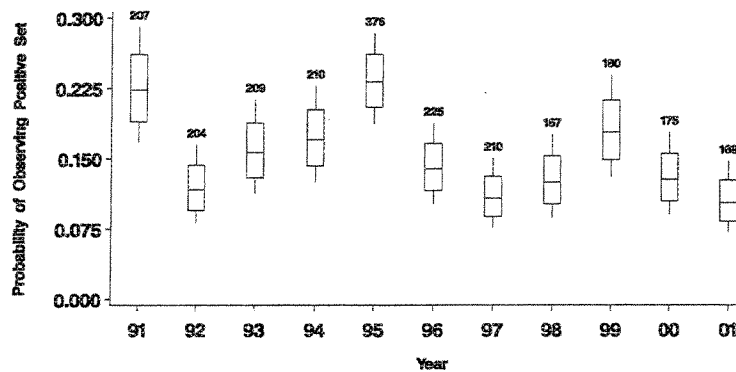


Figure 8. The percentage of Fishery-Independent Monitoring sets that captured young-of-the-year spotted seatrout on the Atlantic coast, 1990–2001

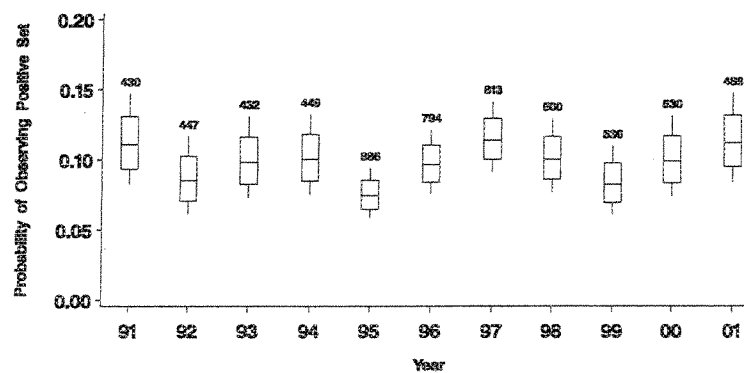
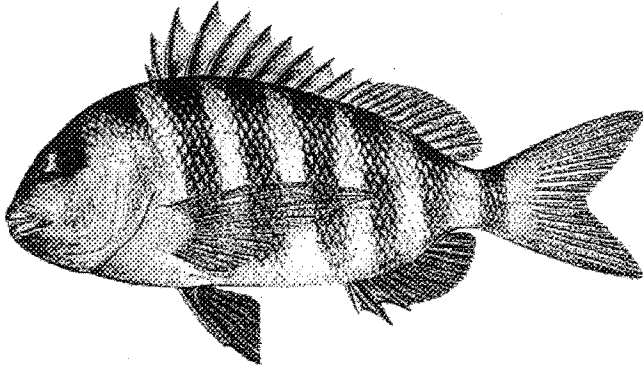


Figure 9. The percentage of Fishery-Independent Monitoring sets that captured young-of-the-year spotted seatrout on the gulf coast, 1989–2001

Sheepshead, *Archosargus probatocephalus*



Sheepshead range from Nova Scotia south to Mexico's Campeche Bank. Very little, genetic stock structure information currently exists regarding sheepshead across their range between North Carolina and Texas (T. Bert, FWC-FMRI unpublished data). Two subspecies, reportedly distinguishable by the number and size of body bars, were thought to occur in Florida (Caldwell 1965). Adult sheepshead feed on algae and invertebrates (Ogburn 1984). Sheepshead apparently mature at age 2. The length of a sheepshead is a poor predictor of its age when it attains fork lengths (FL) greater than about 8 inches. Average predicted size at age 1 in Florida is 8.1 inches FL (FWC-FMRI, unpubl. data). Maximum life span for sheepshead is at least 20 years (Beckman *et al.* 1991). Sheepshead are estuarine dwelling fish; they move offshore to spawn following the onset of cool weather and return to inshore waters in the spring after spawning. They are fractional spawners and estimates of spawning frequency range from daily to once every 20 days (Render and Wilson 1992).

Table 1. Von Bertalanffy growth parameters and length-weight relations for sheepshead

Inches FL = $L_{\infty}(1 - e^{-K(\text{age}-t_0)})$	K	L_{∞} (inches FL)	t_0 (years)	Source
Sexes combined, Atlantic coast, Florida	0.390	15.0	-1.13	McDonald (FMRI, per. comm.)
Sexes combined, gulf coast, Florida	0.242	17.8	-1.17	McDonald (FMRI, per. comm.)

Weight in lbs = $a(\text{inches FL})^b$	a	b	Source
Males, central west Florida	0.00088	3.024	McDonald (FMRI, per. comm.)
Females, central west Florida	0.00114	2.907	McDonald (FMRI, per. comm.)

According to Benson (1982), juvenile sheepshead eat zooplankton as well as polychaetes and larval chironomids; large juveniles and adults prey on blue crab, young oysters, clams, crustaceans, and small fish.

Florida landings of sheepshead were 3,334,751 pounds in 2001. The recreational fishery made about 90% of the statewide landings. Sixty-two percent of the statewide landings in 2001 were made on the gulf coast. During 2001, commercial landings were highest in Martin County on the Atlantic coast and in Lee County on the gulf coast (Fig. 1). Recreational landings in 2001 were highest along the gulf peninsula and the northeast and east-central Florida Atlantic coast

(Fig. 2).

The 2001 total landings of sheepshead were 18% higher than the average landings in the previous five years (1996–2000) and were 8% lower than the 1982–2001 historical average landings (Fig. 3). On the Atlantic coast, total annual landings increased between 1989 and 1994, decreased to 0.84 million pounds through 1998, but increased to over 1.28 million pounds in 2001 (Fig. 3). Gulf coast landings have fluctuated with a peak in 1992, followed by a general decline to 1.65 million pounds through 1997, and except for 1999, when landings were 2.32 million pounds, have held steady at 1.65 million pounds through 2001 (Fig. 3).

Standardized commercial catch rates on the Atlantic coast fluctuated without trend during 1986–2001 (Fig. 4). Commercial catch rates on the gulf coast show a slow, long-term increase (Fig. 5). Total-catch rates by anglers fluctuated without trend on the Atlantic and gulf coasts (Figs 6, 7).

Indices of juvenile abundance for sheepshead show strong year-classes recruiting in 1999, 2000, and 2001 on the Atlantic coast and in 1991 and 2000 on the gulf coast (Figs. 8, 9).

Assessments of sheepshead indicate that they were fished near their maximum yield-per recruit in 1994, but fishing mortality has since declined in response to several management initiatives (Muller and Murphy 1994; Murphy et al. 1997; Murphy and MacDonald 2000). Fishery management actions in the mid 1990s that led to a drop in total landings of sheepshead and a change in the size of fish landed and include restrictions to the use of entangling nets, restricted species designation for sheepshead, the 12-inch FL minimum-size limit, a 10-fish bag limit (changed to 15 fish), and a 50 fish commercial possession limit. The associated decline in fishing mortality and shift in age-specific vulnerability to the fishery has been enough to allow for the increase in the spawning stock of sheepshead in Florida. In response to the drop in fishing mortality, the transitional spawning potential ratios on both coasts have risen steadily since 1996. The estimated transitional SPR has increased from 34% in 1996 to 47% in 2000 on the Atlantic coast and from 39% in 1996 to 49% in 2000 on the gulf coast (Murphy and MacDonald 2000). This increase in spawning stock is enough that recruitment failure for either the Atlantic coast or gulf coast stocks is unlikely. In fact, it appears that the stock could still maintain its production of recruits and provide more yield if fishing mortality were allowed to increase somewhat above 2000 levels.

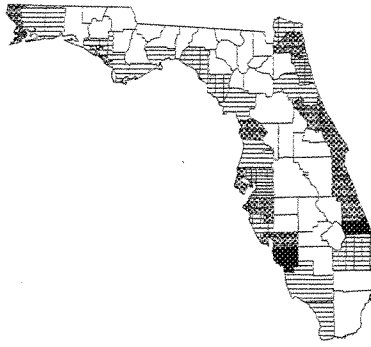


Figure 1. Geographic distribution of commercial landings of sheepshead during 2001

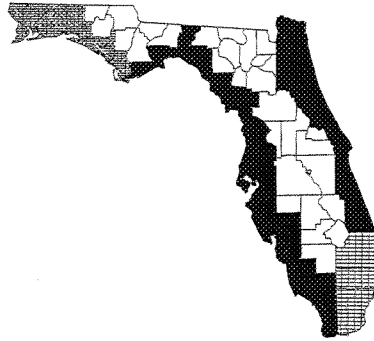


Figure 2. Geographic distribution of recreational landings of sheepshead during 2001

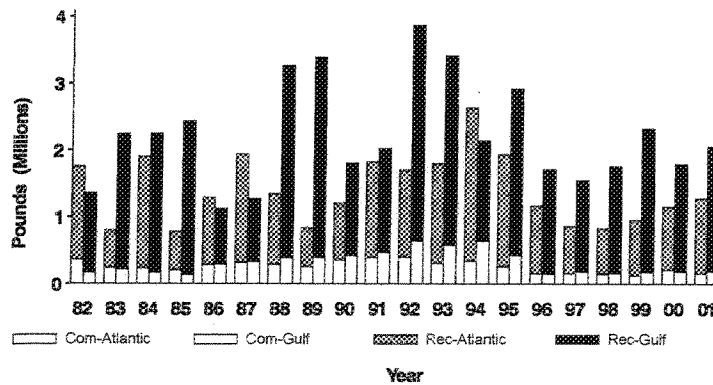


Figure 3. Total annual landings of sheepshead on the Atlantic and gulf coasts of Florida, 1982–2001

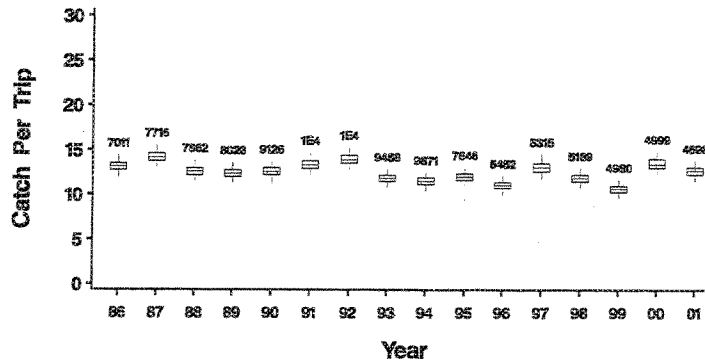


Figure 4. Annual standardized commercial catch rates (pounds) for sheephead on the Atlantic coast of Florida, 1986–2001

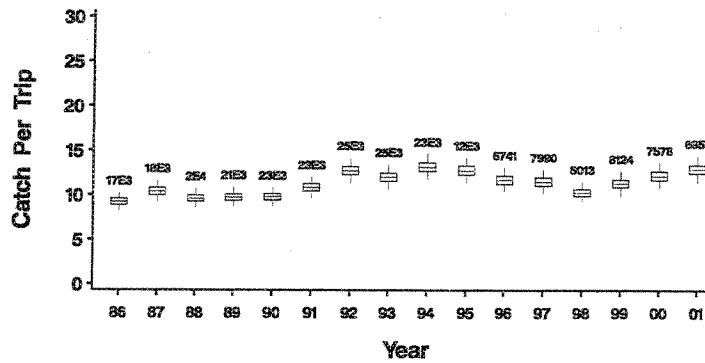


Figure 5. Annual standardized commercial catch rates (pounds) for sheephead on the gulf coast of Florida, 1986–2001

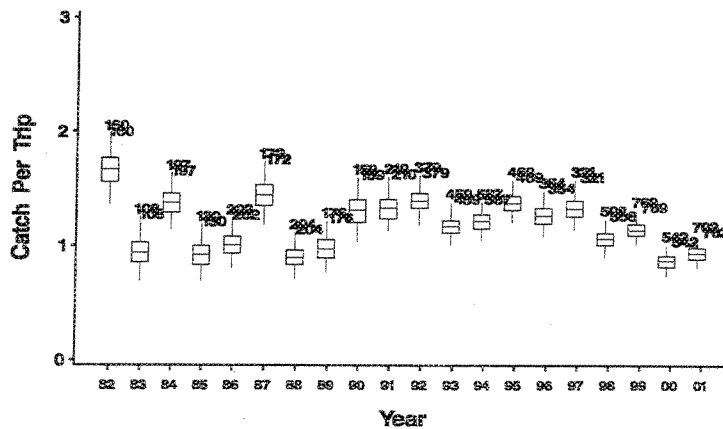


Figure 6. Annual standardized recreational catch rates (numbers) for sheephead on the Atlantic coast of Florida, 1982–2001

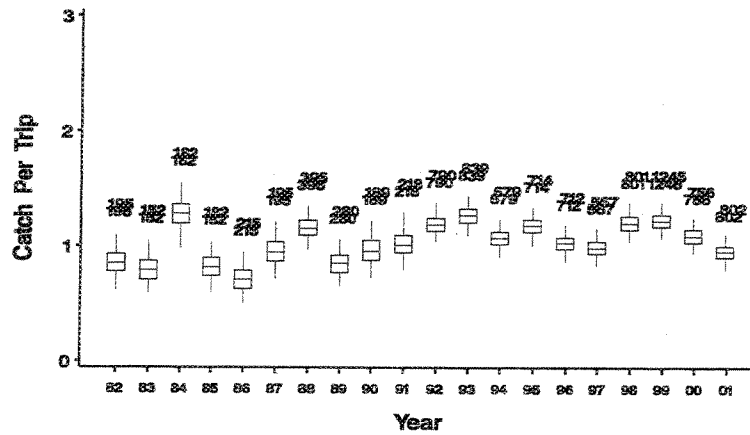


Figure 7. Annual standardized recreational catch rates (numbers) for sheephead on the gulf coast of Florida, 1982–2001

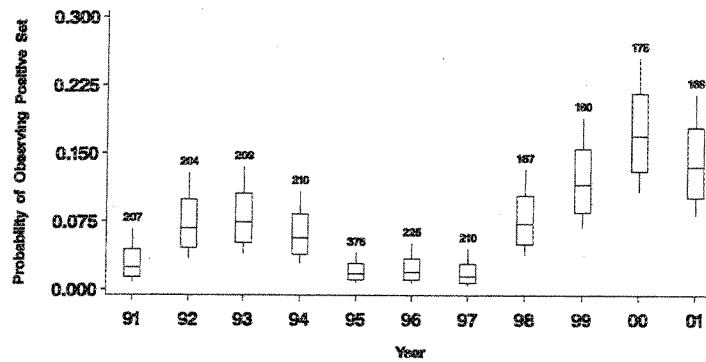


Figure 8. The percentage of Fishery-Independent Monitoring sets that captured young-of-the-year sheephead on the Atlantic coast, 1990–2001

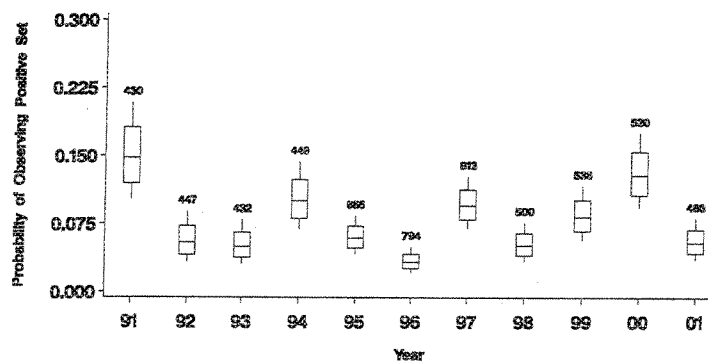


Figure 9. The percentage of Fishery-Independent Monitoring sets that captured young-of-the-year sheephead on the gulf coast, 1989–2001